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UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF TEXAS

SHERMAN DIVISION

The State of Texas, et. al. Plaintiff, v. Google LLC, Defendant.	Case No: 4:20-cv-0095wei7

Expert Report of Jacob Hochstetler

6/7/2024

Jacob Hochstetler

I. INTRODUCTION

A. Assignment

1. I understand that on December 16, 2020, a multistate coalition led by the State of Texas filed a lawsuit against Google LLC (Google) asserting violations by Google of federal and state antitrust laws and violations of other state laws, in connection with Google's conduct in the online display advertising industry and as to digital advertising technologies ("Ad Tech" or "Ad Tech stack"). Currently, 16 States (Texas, Alaska, Arkansas, Florida, Idaho, Indiana, Kentucky, Louisiana, Mississippi, Missouri, Montana, Nevada, North Dakota, South Carolina, South Dakota, and Utah) and the Territory of Puerto Rico are Plaintiffs in the case (Plaintiff States). I have been retained to provide expert analysis and opinions on behalf of all of the Plaintiff States.

2. I have been asked by counsel for the State of Texas, on behalf of all Plaintiff States in this case, to provide opinions regarding the operation of the products used in web display advertising. These products include ad servers, ad exchanges, and the tools used by publishers and advertisers. I have further been asked to provide opinions regarding the design and technical implementation of Google's Display Ads systems, including the DFP ad server, Google Ad Exchange, Google Ads, DV360, and their subsequent versions and variants, based on review of Google source code and production documents. I have also been asked to provide opinions regarding the technical implementation of the conducts within Google's suite of advertising products, including the technical implementation of Dynamic Allocation, Enhanced Dynamic Allocation, Exchange Bidding, Unified Pricing Rules, Bernanke, Dynamic Revenue Share, Reserve Price Optimization, all versions and variants thereof, and the technical integration of the DFP ad server and Google Ad Exchange.

3. I am competent to testify to the matters stated in this Report, have personal knowledge of the facts and statements herein, and each of the statements is true and correct.

4. In preparing this report, I have considered all of the documents referenced in this report as well as those listed in Appendices B and C. I have also relied on my own experience in the field of distributed systems, software engineering at scale, as well as API and infrastructure design. My opinion is based on the source code and documents available to me as of the time of this report. I reserve all rights to supplement my report should any additional information be produced in this case. I further reserve my right to use graphics, figures, and/or illustrations at trial to support my conclusions.

B. Qualifications

5. I am a Clinical Assistant Professor of Computer Science and Engineering at the University of North Texas. With 25 years of industry experience, I specialize in developing and managing software at scale, namely distributed networked systems. My expertise includes web technologies, C++, Golang, and Protocol Buffers. My major open-source work includes contributions to Envoy Proxy, a Cloud Native Computing Foundation project used by Google, and Telegraf, an agent for InfluxDB. My research interests include edge computing and distributed computing. As part of my employment at the University of North Texas, I have taught many courses in software design and engineering. I have also published papers on communications systems, edge computing, scalable datacenters, and the design of big data applications. My research has addressed multiple aspects of system interoperability, both in the context of mobile and non-mobile devices and in the use of machine learning in distributed computing systems.

6. I received my B.S. in Computer Science from the University of North Texas in 2011. After receiving my B.S., I served as UNIX Systems Lead for General Dynamics and the United States Air Force Central Command Intelligence, Surveillance, and Reconnaissance Division, where I provided subject matter expertise to the US military A6, G6, and J6 commands, foreign nations, as well as down-range assets. I also developed real-time self-service web services for the Change-Advisory Board.

7. Since 2015, I have worked for FMR LLC developing computer architecture and creating seamless user integration experiences while maintaining security. I supported the cloud management systems and developed automation resources to meet FMR LLC's strict security, compliance, and audit requirements. While working at FMR LLC, I earned my M.S. in Computer Science (2018) and Ph.D. in Computer Science and Engineering (2021) from the University of North Texas, where I wrote my thesis on an Extensible Computer Architecture Design for Connected Autonomous Vehicle Systems. After earning my Ph.D. I was promoted to Distinguished Engineer and now provide technical leadership for FMR LLC's Platform Engineering teams, develop next-gen frameworks for high-performance applications, and facilitate high-level and cross-business unit architecture teams.

8. Since 2021, I have served as Clinical Assistant Professor at the University of North Texas, where I have designed and taught undergraduate and graduate-level computer science, information technology, and cybersecurity courses. In addition to serving as the Computer

Science curriculum program advisor, I have led the NSA/NSF GenCyber student and teacher summer camps to help train and inspire the next generation of cybersecurity leaders.

9. Further details of my background and experience are provided in my curriculum vitae, which is attached as Appendix D. I am being compensated for my time at a rate of $500 per hour. My compensation does not depend on the outcome of this case or on any opinion that I may offer.

II. EXECUTIVE SUMMARY

10. Section III introduces the process that underlies web display advertising and the tools and platforms that facilitate this process, including ad servers, ad exchanges, ad buying tools and ad networks. Website owners, or publishers, generally use ad servers such as Google's DoubleClick for Publishers (DFP) to manage the ad slots on their websites. Ad exchanges, such as Google Ad Exchange (AdX), are marketplaces for publisher tools to put ad slots up for auction, while buy-side tools bid for their ads to be displayed. DFP and Google Ad Exchange are currently part of a single product, Google Ad Manager (GAM). Advertisers use ad buying tools such as Google Ads and DV360 to manage their ad campaigns and purchase ad slots in real-time.

11. Section IV first provides an overview of the ad serving stack and information flow during the ad serving process. Line items are specific settings and criteria in an ad server that define how, when, and where an advertisement will be delivered and at what cost. Ad tags are segments of code embedded on a publisher's website that communicate with a publisher's ad server to initiate the ad serving process when a user opens a website and to receive the winning advertisement and send it to the browser. User identifiers and information used for purposes such as ad targeting are collected via cookies and provided by publishers. BOW is Google's front-end server that receives requests sent by ad tags. Then the Unified Identity Server (UIS) performs authentication and sends the request to the "Supermixer," which is responsible for routing bid requests and collecting responses from demand sources. A series of targeting servers are responsible for selecting ads from specific demand sources and sending them, along with bid values, to the Supermixer. The relevant targeting servers include: 1) CAT2 mixer, which returns bids from Google buying tools (*e.g.*, DV360 and Google Ads), 2) RTB mixer, which returns bids from third-party buying tools bidding into AdX and Exchange Bidding, and 3) GFP mixer, which returns bids from direct deals with advertisers. When the Supermixer returns the winning ad, BOW is responsible for information formatting and ad rendering.

12. Further, Section IV describes additional capabilities of Google's ad buying tools. AWBid enables Google Ads to bid into third-party exchanges, in addition to Google's Ad Exchange and facilitates Project Yavin, which allows DV360 and Google Ads to buy directly from publishers' ad servers. Section IV then explains how Google's ad serving functionality has changed over time and how it functions today, including the transition away from waterfall to real-time auctions and the introduction of Dynamic Allocation, Enhanced Dynamic Allocation, Header Bidding, Exchange Bidding, and Unified Pricing Rules.

13. Section V describes how AdX was originally designed to be interoperable with third-party ad servers and ad networks. When Google rebuilt the AdX technology in 2009, it was designed to integrate with Google's ad stack (*e.g.*, AdSense, AdWords, DFP); however, publishers and advertisers could use AdX in conjunction with third-party buying tools, ad networks, and/or ad servers. Around 2014, Google began unifying DFP and AdX into a single platform, which culminated in the release of GAM in 2018. Google built a single UI to access both DFP and AdX, integrated DFP and AdX's ad serving infrastructure over time, and built additional features on top of the unified stack. AdX and DFP have separate ad tags (AdX tag and GPT tag, respectively). Google has considered several solutions to direct all GAM traffic through the GPT tag; however, AdX tags are still in use and advertisers are still able to use AdX with a third-party ad server (AdX Direct). While AdX tags and AdX Direct still exist, publishers using AdX tags do not have access to all the features of GPT tags, such as Programmatic Guaranteed, Preferred Deals, Dynamic Allocation, and Exchange Bidding.

14. Section VI describes how Dynamic Allocation (DA) was launched by DoubleClick in 2007. DA enabled AdX and remnant, or non-guaranteed, line items to compete in real-time for impressions not fulfilled by guaranteed line items. At the time, waterfall auctions were used to sell ad slots, where demand sources (*i.e.*, ad exchanges and networks) were ranked in order of historical performance and called sequentially to solicit bids until a demand source provided a suitable ad. This resulted in several inefficiencies, including latency and situations where a publisher may not have maximized their revenue for an impression. With DA, if no guaranteed line item provided a suitable ad, AdX and remnant line items would compete against each other and the winning ad would be served. In the event that there was no eligible remnant line item or a winning AdX candidate, the publisher would promote its own products or services. When DA was launched, AdX was the only exchange with the technical capability to submit real-time bids into DFP, and therefore, participate in DA. Google acquired a "yield manager" platform in 2011 called AdMeld that supported real-time bidding (RTB), (*i.e.*, handling bids from multiple demand

sources to compete in a single real-time auction). After acquiring AdMeld, Google began developing "Third-Party Dynamic Allocation" (3PDA), which would have allowed AdX buyers to compete with demand sources engaging in real-time bidding through AdMeld in an AdMeld-hosted auction for AdMeld publisher inventory. However, Google ultimately did not release 3PDA.

15. Section VII describes how Google introduced Enhanced Dynamic Allocation (EDA) in March 2014, which allowed AdX and remnant line items (*e.g.*, third-party exchanges) to compete against guaranteed line items in real-time, while still protecting guaranteed line items' campaign goals. With EDA, publishers may have lost out on revenue from guaranteed and remnant demand sources because while AdX competed for impressions with real-time bids, guaranteed and remnant line items competed using static CPMs. Google transitioned all publishers to EDA by 2016 and did not offer a direct way for publishers to disable or turn off EDA. To circumvent EDA, a publisher could either disable AdX for a single impression or use AdX tags, which are limited in functionality. Within EDA, DFP used remnant line items, which were selected to compete using real-time bids from external third-party buyers, to calculate AdX's price floor. This gave AdX buyers a "Last Look" at other buyers' prices before submitting bids. Last Look led to situations where AdX won auctions that it would have otherwise lost without Last Look. However, Google did not use bids from third-party buyers bidding through Google's own products to inform AdX auction price floors in Last Look. I understand that EDA is still in use today, and that in 2019 Google effectively removed the Last Look from EDA.

16. Section VIII discusses how in 2014, Header Bidding was introduced to resolve the technical challenges associated with waterfall auctions and to promote real-time bidding outside of Google's ad stack. Header Bidding allowed publishers to offer their ad inventory to multiple exchanges simultaneously. Hence, publishers were able to select the winner based on the highest real-time bid, instead of the bidders' historical performance. Header Bidding is implemented by placing HTML or JavaScript code on a publisher's website, which runs an auction for different demand sources before sending the winning bid to the ad server. Header Bidding can be of two types – client-side and server-side – based on whether it is run on the user's browser or an external server. Winning Header Bidding bids are sent into GAM as line items and compete with AdX buyers in real-time. Since Header Bidding bids are usually matched to remnant line items, AdX buyers had a Last Look over Header Bidding buyers until 2019 when Last Look was removed.

17. Section IX describes the introduction of Exchange Bidding by Google in 2018 as its server-side alternative to Header Bidding. With Exchange Bidding, a single bid request is sent from the publisher webpage to Google Ad Manager, which then sends bid requests to all participating bidders, including both AdX and third-party exchanges, to compete in a single real-time auction. Exchange Bidding was implemented on an external server to purportedly reduce latency according to Google. But this server-side implementation also resulted in reduced visibility into the auction dynamics on the external server. I understand that unlike buyers using Header Bidding, the bids of buyers using Exchange Bidding were not used to inform the AdX floor. Moreover, Exchange Bidding participants were also granted the Last Look over Header Bidding bids.

18. Section X discusses the introduction of Project Bernanke, an internal Google program, in 2013 to adjust advertiser bids and increase the numbers of auctions won by Google Ads in AdX. Project Bernanke was implemented in four phases – "Original Bernanke" in 2013, "Global Bernanke" in 2015, "Project Bell v2" in 2016 and "1P Bernanke" in 2019. Original Bernanke, Global Bernanke, and 1P Bernanke all maintained Bernanke pool(s) of money to subsidize bids in auctions where Google Ads bids would have lost, and recouped money through bid adjustments in auctions where bids from Google Ads bidders ranked on top. Google employed a series of background experiments to calculate the multipliers used to adjust the bids sent by Google Ads. The original version of Project Bernanke adjusted bids while creating a Bernanke pool per publisher and maintained a fixed margin per publisher. Global Bernanke changed the per-publisher pool to a single pool shared among all publishers. Finally in 2019, Google adjusted the Bernanke algorithm to accommodate the switch to a first-price auction.

19. Section XI discusses Google's launch of Dynamic Revenue Share (DRS) in 2015, which modified the take rate in AdX auctions to clear more auctions. Google released three versions of DRS. DRS v1 lowered the AdX take rate if that allowed the highest AdX bid to clear the auction. DRX v2, launched in December 2016, allowed Google to raise the AdX take rate to counterbalance the auctions in which the take rate was lowered by DRS. Finally, Truthful DRS (tDRS) launched in July 2018 and employed a machine learning model to predict the AdX revenue share that was necessary for the highest bid to clear the auction.

20. Section XII describes Project Poirot, launched in 2017, that reduces DV360 spend in second-price auctions[1] with "soft" floors, which are floors that allow bids below the floor to win.

[1] In a second-price auction, the highest bidder wins but pays the amount of the second-highest bid.

Project Poirot is designed to detect deviations from second-price auctions and have DV360 bid less in those exchanges. Google runs daily background experiments for each advertiser and exchange pairing and uses a machine learning algorithm trained on seven days of DV360 data to determine the amount to lower a bid. Google launched additional versions of Project Poirot, including Poirot with Bid Buckets, Poirot with Auction Type Signal, and a version incorporating minimum bid to win data from GAM. Google has also extended Poirot to run on AdWords (an older version of Google Ads) and has launched Project Marple, which applies the same methodology to Google Ads.

21. Section XIII discusses how Google introduced multiple versions of Reserve Price Optimization (RPO) to automatically increase auction reserve prices that Google predicts are too low compared to the value of publisher inventory. Google uses machine learning models to set the increased auction reserve prices as close to the expected highest bid as possible while clearing their margin requirements to ensure the transaction completes. There were two types of RPO: second-price RPO, which was a no opt-out feature that functioned from 2015 until 2019 and first-price RPO which is an optional feature that was rolled out in 2022 and functions to this day. Second-price RPO generated per-buyer reserve prices for second-price auctions. First-price RPO was rolled out following Google's switch to first-price auctions and operates similarly while accounting for changed bidder behavior.

22. Section XIV discusses Unified Pricing Rules (UPR), which were introduced in 2019 and accompanied Google's shift from a second-price auction in AdX to a unified first-price auction where bids from all demand sources in GAM competed at the same time. UPR introduced several changes to Google's auction dynamics with regards to how publishers could set price floors (also known as "pricing rules"). Prior to UPR, publishers could set price floors for each buyer and advertiser through GAM; set price floors for a third-party exchange by using that exchange's platform; assign a priority for each price floor to dictate which floor would take precedence if two floors overlapped with each other during an auction; and specify how much information about the webpage visited by the user could be shared with buyers. However, prior to UPR, publishers could not use GAM to configure price floors for third-party exchanges, and would have to set price floors for these exchanges through an interface provided by the exchange. The launch of UPR resulted in uniform price floors that applied to all buyers; as a result, publishers could no longer set per-buyer price floors. Similarly, publishers were more limited in the number of price floors that could create per GAM account and in the amount of information they could share with buyers.

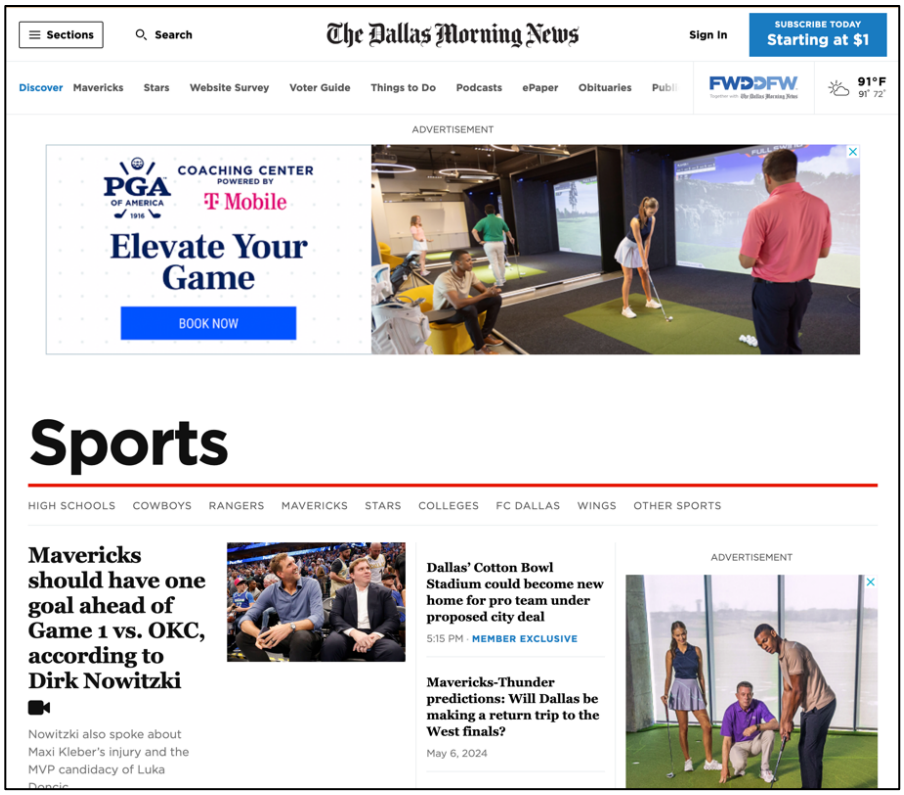
Some publishers attempted to circumvent UPR using "house" line items, but Google updated its line item policy to prevent what it called "invalid activity" from publishers bypassing UPR.

III. INTRODUCTION TO WEB DISPLAY ADVERTISING TECHNOLOGY

23. When a user navigates to a website that displays advertisements, such as an online news publisher, the ads that the user sees on that webpage are the result of an automatic ad selection process that runs in real-time as the page loads.[2] This ad selection process often involves a real-time ad auction.[3] The owner of the website allocates a number of "slots" on each page, each of which can contain an ad.[4] When an individual user sees an ad that is placed in a slot, it is called an "impression."[5] In display advertising auctions, advertisers bid for the chance to have their ad shown on a particular webpage in a particular slot to a particular user (generally someone in their target audience).[6] A number of ad technology products are involved in sending requests for ads to the auction, selecting the winning bidder, and showing the winning ad to the user.[7] Figure 1 shows an example of a winning advertisement, in this case an ad for the Professional Golfers' Association of America on the Sports page of the Dallas Morning News. This section of my report discusses the ad serving process, as well as the platforms and tools that facilitate this process.

[2] Khor N., Publift, "What is Programmatic Advertising? How Does it Work?" (April 8, 2024) https://www.publift.com/adteach/what-is-programmatic-advertising. Accessed May 23, 2024.
[3] Khor N., Publift, "What is Programmatic Advertising? How Does it Work?" (April 8, 2024) https://www.publift.com/adteach/what-is-programmatic-advertising. Accessed May 23, 2024.
[4] Clearcode, "Ad slot," https://clearcode.cc/glossary/ad-slot-definition/. Accessed May 23, 2024.
[5] adjust, "What is an impression?" https://www.adjust.com/glossary/impression/. Accessed April 23, 2024.
[6] Khor N., Publift, "What is Programmatic Advertising? How Does it Work?" (April 8, 2024) https://www.publift.com/adteach/what-is-programmatic-advertising. Accessed May 23, 2024.
[7] Khor N., Publift, "What is Programmatic Advertising? How Does it Work?" (April 8, 2024) https://www.publift.com/adteach/what-is-programmatic-advertising. Accessed May 23, 2024.

Figure 1: An ad for PGA America on the Sports page of the Dallas Morning News

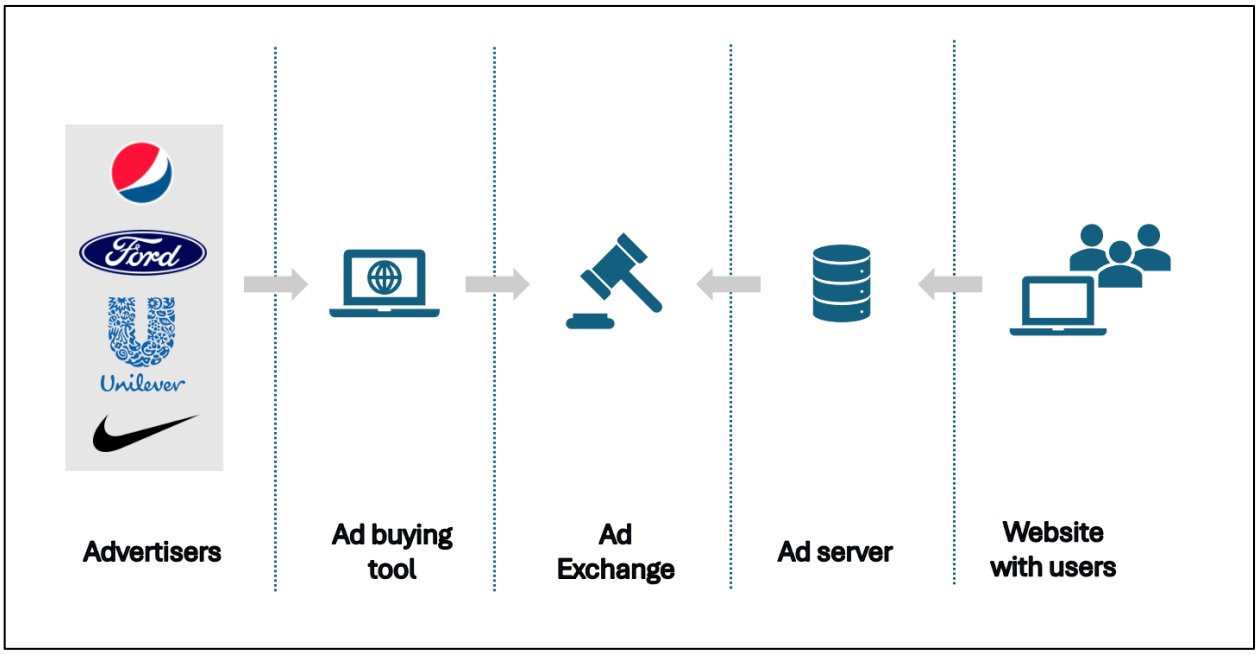


24. Various advertising technology platforms and tools facilitate the ad serving process, including publisher ad servers, ad buying tools, and ad exchanges.[8] Figure 2 provides an overview of the process of serving an advertisers' ad via an ad exchange to a user visiting a publisher's website. Website owners, also known as publishers, use ad servers to manage their display ad inventory (the various slots on their webpages that can display ads) and to find ads to fill those slots (referred to as "demand" in the display advertising industry).[9] Advertisers use ad buying tools to manage their display ad campaigns, designate user targeting criteria for their advertisements (*e.g.*, based on demographics, geography, online behavior etc.), and set goals for their ad campaigns.[10] An ad campaign is a set of related advertisements with the same objectives,

[8] Urwin M., builtin, "Adtech Definition," (Sept 27, 2022) https://builtin.com/adtech-martech. Accessed May 23, 2024.
[9] Amazon Ads, "Ad Servers and how they work," https://advertising.amazon.com/library/guides/ad-server. Accessed June 5, 2024.
[10] As described in Section III.C, ad buying tools can include buying tools for large advertisers, sometimes referred to as DSPs, and buying tools for small advertisers such as Google Ads; Description of capabilities of DSPs, adjust, "What is a demand-side platform (DSP)?" https://www.adjust.com/glossary/demand-side-platform/. Accessed May 23, 2024; Examples of set-up pages from different buyside tools: Trade Desk: Partner portal, "Campaign," https://partner.thetradedesk.com/v3/portal/api/doc/Campaign. Accessed May 23, 2024; Google Ads: Google Ads Help, "Create a campaign,"

budget, dates, and conversion events.[11] For example, an advertiser may set up a display ad campaign with the objective of getting as many site visits as possible between the dates of January 1st and February 1st by 20- to 40-year-old women who are interested in golf and located in Dallas, TX. Google's ad buying tools allow an advertiser to specify a campaign type or creative type (*e.g.*, Display Campaign or Video Campaign) based on the campaign's goals.[12] Ad exchanges primarily facilitate programmatic ad deals, such as by conducting ad auctions where publishers and advertisers connect to buy and sell impressions.[13,14]

Figure 2: Overview of the ad serving process via an ad exchange[15]



https://support.google.com/google-ads/answer/6324971. Accessed May 21, 2024; DV360: Display & Video 360 Help, "Create a campaign," https://support.google.com/displayvideo/answer/7205081. Accessed May 23, 2024.

[11] Examples of set-up pages from different buyside tools: Trade Desk: Partner portal, "Campaign," https://partner.thetradedesk.com/v3/portal/api/doc/Campaign. Accessed May 21, 2024.

[12] Google Ads: Google Ads Help, "Create a campaign," https://support.google.com/google-ads/answer/6324971. Accessed May 21, 2024; DV360: Display & Video 360 Help, "Create a campaign," https://support.google.com/displayvideo/answer/7205081. Accessed May 21, 2024.

[13] The Trade Desk, "Glossary," https://www.thetradedesk.com/us/glossary. Accessed June 5, 2024.

[14] Amazon Ads, "What is an ad exchange? Learn how they work," https://advertising.amazon.com/library/guides/ad-exchange. Accessed June 5, 2024.

[15] This is meant to serve as a simplified overview of the ad serving process via an ad exchange, based on an internal Google document, "SF Programmatic Primer," GOOG-AT-MDL-003565982 at '994 (CI).

25. Google owns and operates all three of the advertising technology products described above. Namely, Google owns a publisher ad server called DoubleClick for Publishers,[16] an ad exchange called Google Ad Exchange and two ad buying tools, Google Ads and DV360.[17]

26. Ad networks act as an intermediary that buys ad inventory from publishers in bulk and sells it to advertisers, as opposed to ad exchanges that function more as a marketplace.[18,19] Google's ad network includes Google Display Network (GDN), which advertisers can use to run display campaigns, and AdSense, the publisher-facing tool in Google's ad network.[20,2122] AdSense fills publisher ad slots with demand from Google Ads (Google's ad buying tool for small advertisers), DV360 (Google's ad buying tool for large advertisers), and third-party buyers in AdX.[23] AdSense is less sophisticated in its ad-serving capabilities than DFP and offers less diversity of ad sources; however, it is designed to be easy to set up and can be used by small publishers with less sophisticated ad campaigns.[24]

A. Ad servers: publishers' tools for managing and selling inventory

27. A publisher operating a website has the option to monetize their display inventory by either utilizing an ad server or an ad network.[25] An ad server is a software platform that manages and distributes publishers' display inventory by keeping a record of their direct deals with

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[16] DoubleClick for Publishers and Google Ad Exchange are currently marketed together under the name "Google Ad Manager." Internal Google documents as well as some industry sources still refer to the products separately. Where it is necessary for clarity, I refer to the two products as separate in this report. Bellack J., Google Ad Manager, "Introducing Google Ad Manager," (June 27, 2018) https://blog.google/products/admanager/introducing-google-ad-manager/. Accessed May 23, 2024.
[17] [redacted] Deposition, (April 26, 2024) at 263:18-21; [redacted] Deposition, (April 26, 2024) at 23:2-10.
[18] The Trade Desk, "Glossary," https://www.thetradedesk.com/us/glossary. Accessed June 5, 2024.
[19] Amazon, "What is an ad exchange? Learn how they work," https://advertising.amazon.com/library/guides/ad-exchange. Accessed June 5, 2024.
[20] Google Ads is often referred to in internal documents as "AdWords" or "Google Display Network" (GDN). Some documents refer to GDN as AdSense and Google Ads together, while others refer GDN as just Google Ads. [redacted] Deposition, (April 19, 2024) at 23:16-17; Google internal document, "Google Display Network Launch," GOOG-TEX-00820709 at '710 and '714 (HCI).
[21] Google Ads Help, "About Display ads and the Google Display Network," https://support.google.com/google-ads/answer/2404190. Accessed June 6, 2024.
[22] Google internal document, "AViD Serving Architecture (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '698 (HCI).
[23] Google internal document, "AViD Serving Architecture (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '698 (HCI).
[24] Zaiceva A., setupad, "Google AdX vs. Google AdSense | Difference Explained," (December 16, 2021) https://setupad.com/blog/adsense-vs-ad-exchange/. Accessed May 30, 2024; [redacted] Deposition, (April 26, 2024) at 264:16-265:15.
[25] Playwire, "Ad Server vs. Ad Network," https://www.playwire.com/blog/ad-server-vs-ad-network. Accessed May 23, 2024.

advertisers, routing available inventory to ad exchanges, and determining which ad to show in real-time.[26] Google owns a publisher ad server called DoubleClick for Publishers (DFP).[27]

28. A key role of an ad server is to determine the ads that will be displayed on the publisher's website. To achieve this, an ad server typically performs three critical tasks: (1) collecting information about the users visiting the publisher webpage and passing it down the ad tech "stack," (2) routing publisher inventory to direct and indirect demand sources, and (3) selecting the winning ad and communicating the information back to the web browser.[28,29]

29. First, the ad server collects information on the user visiting the webpage through a browser-facilitated identification technology called "cookies."[30] Cookies are small files or pieces of data stored on a user's device that allow websites and services the user interacts with online to identify or authenticate the user.[31] Cookies may also contain user-specific information, including login credentials and browsing history.[32] They are collected and used by ad servers to track users' online behavior over time and display targeted ads tailored to the individual's interests and preferences.[33] For example, if a user, who has been classified as "interested in athletics" based on their browsing history, views an article in online Runner's World magazine, the ad server used by Runner's World may serve the user an Adidas sneaker ad.

30. Second, the ad server allocates and routes publishers' inventory across direct and indirect demand sources.[34] Direct demand represents direct agreements between the publisher and advertisers, often involving a specific negotiated price and an agreed-upon volume or percentage

[26] Amazon Ads, "Ad Servers and how they work," https://advertising.amazon.com/library/guides/ad-server. Accessed June 5, 2024.
[27] AdSense is out-of-scope for this report but is mentioned here to explain the serving stack and certain programs.
[28] Sweeney M., Zawadzinski M., clearcode, "What is an Ad Server and How does it work," (March 14, 2024) https://clearcode.cc/blog/what-is-an-ad-server/. Accessed May 23, 2024.
[29] There are other ways a publisher ad server can collect publisher information such as PPID, which is described in detail in Section IV.C. Google Ad Manager Help, "About publisher provided identifiers," https://support.google.com/admanager/answer/2880055. Accessed May 23, 2024.
[30] Barth A., Internet Engineering Task Force (IETF) Request for Comments (RFC) 6265, "HTTP State Management Mechanism" (April 2011) https://datatracker.ietf.org/doc/html/rfc6265. Accessed June 5, 2024.
[31] [redacted] Deposition, (May 3, 2024) at 527:17-23.
[32] Mozilla Support Firefox Help, "Cookies - Information that websites store on your computer" (July 29, 2023) https://support.mozilla.org/en-US/kb/cookies-information-websites-store-on-your-computer. Accessed June 5, 2024.
[33] Amazon Customer Service, "About Cookies" (January 1, 2020) https://www.amazon.com/gp/help/customer/display.html?nodeId=GV. Accessed June 5, 2024.
[34] Sweeney M., Zawadzinski M., clearcode, "What is an Ad Server and How does it work," (March 14, 2024) https://clearcode.cc/blog/what-is-an-ad-server/. Accessed May 23, 2024.

of ads to be displayed within a designated timeframe.[35] Such agreements can be negotiated under varying terms.[36] Traditional direct demand involved purchasing ad inventory at a fixed price and managing the insertion of the ad manually. In contrast, "programmatic direct" involves an agreement between publishers and advertisers, but the process of selecting the ad based on targeting and placing the ad on the publisher's website is performed automatically.[37] For example, publishers and advertisers can negotiate a "Programmatic Guaranteed" deal. In this case, the publisher and the advertiser negotiate terms and price for a given segment of the publisher's inventory, which is then guaranteed to be sold to that advertiser at that price.[38] For instance, a publisher may make a deal with Nike that guarantees that Nike ads will be shown on 50% of publisher's ad space in the span of a month at a price of $5.00 for every 1000 impressions. Publishers and advertisers can also negotiate a "Preferred Deal," where both parties similarly agree on terms and a price for specific inventory. However, unlike Programmatic Guaranteed, there is no binding obligation for the publisher to sell or the advertiser to buy said inventory. In other words, the advertiser has a "preferred" opportunity to place a bid for the inventory before other demand sources, but the inventory is not reserved for that advertiser, nor is the advertiser required to buy it.[39] Both types of direct deals may be recorded in the ad server, which then determines the optimal way to allocate inventory and display ads.[40] Programmatic Guaranteed and Preferred Deals are collectively referred to as "Programmatic Direct," denoting the programmatic (or automatic) sale of ad inventory negotiated through direct deals.[41]

31. In contrast, indirect (or "Programmatic") demand represents buyers that do not have a direct relationship or agreement with the publisher and instead compete for the publisher's

[35] Munro B., Publift, "What is Programmatic Direct," (April 8, 2024) https://www.publift.com/blog/what-is-programmatic-direct. Accessed April 11, 2024; Google Ad Manager Help, "Programmatic Guaranteed vs. Preferred Deals," https://support.google.com/admanager/answer/7637485. Accessed May 23, 2024.
[36] Munro B., Publift, "What is Programmatic Direct," (April 8, 2024) https://www.publift.com/blog/what-is-programmatic-direct. Accessed April 11, 2024; Google Ad Manager Help, "Programmatic Guaranteed vs. Preferred Deals," https://support.google.com/admanager/answer/7637485. Accessed May 23, 2024.
[37] Seth A., adpushup, "Programmatic Deals vs. Direct Deals – Simplified Advertising Comparison," (March 29, 2024) https://www.adpushup.com/blog/programmatic-vs-direct-deal/. Accessed May 23, 2024.
[38] Google Ad Manager Help, "Programmatic Guaranteed vs. Preferred Deals," https://support.google.com/admanager/answer/7637485. Accessed May 23, 2024.
[39] Google Ad Manager Help, "Programmatic Guaranteed vs. Preferred Deals," https://support.google.com/admanager/answer/7637485. Accessed May 23, 2024.
[40] Munro B., Publift, "What is Programmatic Direct," (April 8, 2024) https://www.publift.com/blog/what-is-programmatic-direct. Accessed May 23, 2024; Sweeney M., Zawadzinski M., clearcode, "What is an Ad Server and How does it work," (March 14, 2024) https://clearcode.cc/blog/what-is-an-ad-server/. Accessed May 23, 2024.
[41] Munro B., Publift, "What is Programmatic Direct," (April 8, 2024) https://www.publift.com/blog/what-is-programmatic-direct. Accessed May 23, 2024.

inventory via auctions.[42] If any segment of publisher ad space is not filled via a direct deal with an advertiser, the ad server solicits bids from indirect channels.[43] In this process, a request is sent to different ad exchanges and networks to solicit bids from other demand sources.[44] A "price floor," alternatively known as "floor price" or "reserve price," denotes the minimum amount a publisher is willing to accept for a particular ad placement.[45] This value, typically configured through the ad server interface, is included in each request to let the demand sources know the minimum price they must beat for their bid to be eligible to compete in the auction.[46]

32. Finally, once the ad server receives all the bids, it determines the final winner among all ads aggregated from the different sources. The winning ad is sent back to the browser, which in turn, renders the ad and makes it visible to the user.[47]

33. In addition to determining which ads are displayed on a publisher website, ad servers provide publishers with insights into the performance of ads served on their website, including the number of ads that are displayed on a particular page and amounts paid by advertisers for the corresponding impressions. Ad servers may also provide forecasting information projecting a publisher's sales and website users, along with other capabilities, such as algorithms that can help publishers intelligently set the price minimums for their inventory.[48]

34. Publisher websites communicate with ad servers using "ad tags." Ad tags are pieces of code inserted into the publisher webpage that are executed by a user's browser as part of loading the

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[42] Seth A., adpushup, "Programmatic Deals vs. Direct Deals – Simplified Advertising Comparison," (March 29, 2024) https://www.adpushup.com/blog/programmatic-vs-direct-deal/. Accessed May 23, 2024.
[43] In reality, this is slightly more complicated. Programs such as DA and EDA, described in Sections VI and VII, may determine that a bid from AdX should serve, even if a direct deal line items is available. Sweeney M., Zawadzinski M., clearcode, "What is an Ad Server and How does it work," (March 14, 2024) https://clearcode.cc/blog/what-is-an-ad-server/. Accessed May 23, 2024.
[44] Vaibhav P., aniview, "What is an ad server? How does ad serving work?" (April 20, 2023) https://aniview.com/what-is-an-ad-server-how-does-ad-serving-work/. Accessed May 23, 2024.
[45] headerbidding, "Price Floor Optimization – a Guide for Publishers," (February 20, 2024) https://headerbidding.co/price-floor-optimization/. Accessed May 23, 2024.
[46] headerbidding, "Price Floor Optimization – a Guide for Publishers," (February 20, 2024) https://headerbidding.co/price-floor-optimization/. Accessed May 23, 2024.
[47] Sweeney M., Zawadzinski M., clearcode, "What is an Ad Server and How does it work," (March 14, 2024) https://clearcode.cc/blog/what-is-an-ad-server/. Accessed May 23, 2024.
[48] Zaiceva A., setupad, "What is an Ad Server & 10 Best Ad Servers for Publishers," (April 17, 2024) https://setupad.com/blog/ad-server/. Accessed May 23, 2024; GAM provides floor optimization algorithms like target CPMs and optimized floors and a variety of metrics that can be included in reports. *See* Google Ad Manager Help, "Unified pricing rules," https://support.google.com/admanager/answer/9298008. Accessed May 23, 2024; Google Ad Manager Help, "Ad Manager report metrics," https://support.google.com/admanager/table/7568664. Accessed May 23, 2024.

webpage.[49] Generally, the ad server generates the code for an ad tag via the ad server interface and the publisher places the tag within the code on their page.[50] When a user opens the publisher's website, the ad tag is activated and sends a signal to the publisher ad server with a request for ads.[51] Ad tags are described in detail in Section IV.B.

35. **DoubleClick for Publishers (DFP)**[52] is Google's ad server that is used by larger publishers with a significant number of direct advertisement sales.[53] DFP is currently part of **Google Ad Manager (GAM)** along with Google's Ad Exchange, which is described in detail in Section III.B.[54] GAM offers two plans: GAM small business and GAM 360, which are designed for medium-large publishers and enterprise-size publishers, respectively.[55] GAM 360 is available to publishers with more than 90 million monthly impressions, requires a contract with Google, and offers a variety of reporting and ad auction features that are not available to GAM small business customers.[56]

36. Publishers using DFP set up their ad inventory and create "line items" to represent their transactions, both from direct deals with advertisers and ad agencies and from ad networks and exchanges, as described in detail in Section IV.A.[57] Publishers define spaces on their website designated for ads and use DFP to generate Google ad tags to place on their website.[58] To determine which exchanges and networks can bid on segments of their inventory, publishers

[49] Seth A., adpushup, "What are Ad Tags and Why Do They Matter," (March 29, 2024) https://www.adpushup.com/blog/ad-tags/. Accessed May 23, 2024.
[50] Munro B., Publift, "Ultimate Guide to Ad Tags," (March 20, 2024) https://www.publift.com/blog/ultimate-guide-to-ad-tags. Accessed May 23, 2024.
[51] Munro B., Publift, "Ultimate Guide to Ad Tags," (March 20, 2024) https://www.publift.com/blog/ultimate-guide-to-ad-tags. Accessed May 23, 2024.
[52] Now combined with AdX to form Google Ad Manager (GAM).
[53] "Google Ad Manager is an ad management platform for large publishers who have significant direct sales." Google Ad Manager Help, "Compare Ad Manager, AdSense, and AdMob," https://support.google.com/admanager/answer/9234653. Accessed May 23, 2024.
[54] Bellack J., Google Ad Manager, "Introducing Google Ad Manager," (June 27, 2018) https://blog.google/products/admanager/introducing-google-ad-manager/. Accessed May 23, 2024.
[55] Abhilasha, headerbidding, "Google Ad Manager or Google Ad Manager 360 – What Should a Publisher Choose?" (December 20, 2023) https://headerbidding.co/google-ad-manager-vs-ad-manager-360/. Accessed May 23, 2024.
[56] Abhilasha, headerbidding "Google Ad Manager or Google Ad Manager 360 – What Should a Publisher Choose?" (December 20, 2023) https://headerbidding.co/google-ad-manager-vs-ad-manager-360/. Accessed May 23, 2024.
[57] Google Ad Manager Help, "Advertising with Google Ad Manager," https://support.google.com/admanager/answer/6022000. Accessed May 23, 2024; Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[58] Google Ad Manager Help, "Advertising with Google Ad Manager," https://support.google.com/admanager/answer/6022000. Accessed May 23, 2024.

utilize "yield groups" within DFP.[59] More specifically, they can select inventory types and ad formats within each yield group and specify which ad exchanges, including Google Ad Exchange and third-party exchanges, and ad networks can bid on the inventory in that group.[60]

37. Within DFP, publishers can set fixed floors or use one of DFP's "floor optimization" options that allow publishers to relinquish some or all control over setting their floors to Google.[61] The floors sent to ad exchanges and ad networks are ultimately determined using a combination of publisher-configured values as well as values calculated by various applicable programs within DFP.[62] A detailed overview of the evolution of pricing floors and what has factored into their calculation is described in Section XIV.

38. DFP publishers can view various reports and metrics on the performance of ads on their website and receive payment for displaying the ads.[63] For example, a "historical report" within DFP would include data on clicks, revenue, click-throughs, and total impressions for select date ranges in the past, while a "future sell-through report" would include predicted impression data for dates in future.[64] Publishers using DFP are generally paid for the number of ads shown on their website once per month.[65]

B. Ad Exchanges: Marketplaces for transacting web display inventory

39. Ad exchanges are a type of ad technology used to buy and sell ad impressions in real-time.[66] Ad exchanges are analogous to digital auction houses, where ad servers and other publisher tools put impressions up for auction, while buy-side tools place bids for their ads to be displayed in that space. One common way ad exchanges generate revenue is by collecting a

[59] Google Ad Manager Help, "Create and manage yield groups," https://support.google.com/admanager/answer/7390828. Accessed May 23, 2024.
[60] Google Ad Manager Help, "Create and manage yield groups," https://support.google.com/admanager/answer/7390828. Accessed May 23, 2024.
[61] Google Ad Manager Help, "Unified pricing rules," https://support.google.com/admanager/answer/9298008. Accessed May 23, 2024.
[62] Examples of these programs include reserve price optimization (RPO), First Look, and others.
[63] Google Ad Manager Help, "Create a new report," https://support.google.com/admanager/answer/2643320. Accessed May 23, 2024; Google Ad Manager Help, "Payment rules," https://support.google.com/admanager/answer/2671028. Accessed May 23, 2024.
[64] Google Ad Manager Help, "Report types in Ad Manager," https://support.google.com/admanager/answer/10117711. Accessed May 23, 2024.
[65] Publisher are paid if they reach their account threshold, if not the balance rolls over to the next month and is paid to the publisher once the threshold is met. Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[66] Munro B., Publift, "What is an Ad Exchange and How Does it Work?" (March 20, 2024) https://www.publift.com/blog/what-is-an-ad-exchange. Accessed May 23, 2024.

percentage of the clearing price (*i.e.*, the price at which the publisher is willing to sell and the advertiser is willing to buy) in the auction, similar to the fee that an auctioneer or an auction house charges when conducting an auction of physical goods.[67] This fee charged by the ad exchange is often referred to as a "take rate" or "revenue share."[68]

40. Ad exchanges help facilitate real-time bidding (RTB), which is the process of buying and selling advertisements in an instantaneous auction as the page loads.[69] Prior to real-time bidding, advertisers primarily made direct deals with publishers to purchase ad slots in bulk. These deals specified the ad space, volume, timeframe, and a pre-determined price for which the advertiser's ads would be displayed on the publisher's webpage.[70]

41. With the introduction of real-time bidding in 2009, advertisers have had the option to continue making direct deals with publishers or to bid for an opportunity to display their ad to a particular user at the very moment the user visits the publisher webpage. Therefore, with real-time bidding, publishers and advertisers have additional information about the ad slot, such as information about the user expected to view the ad. This enables the ad space to be sold at varying prices based on its perceived value.[71] The process of real-time bidding occurs in the time span of approximately 100 milliseconds.[72]

42. After the introduction of real-time bidding, to meet their contractual obligations, publishers would prioritize the sales of directly negotiated inventory first. Any remaining ad space would be routed to ad networks and ad exchanges, which were called sequentially in an order determined by the publisher until one was able to meet the price floor and return a qualifying ad.[73] This process is referred to as the waterfall process, which I explain in further detail in Section IV.J. After the waterfall model, several ad selling models, such as Header Bidding, were developed

[67] Greenfield I., mntn, "Ad Exchange: What Is It and How Does it Work?" https://mountain.com/blog/what-is-an-ad-exchange/. Accessed May 23, 2024.
[68] [redacted] Deposition, (April 26, 2024) at 180:16-181:12.
[69] Munro B., Publift, "What is an Ad Exchange and How Does it Work?" (March 20, 2024) https://www.publift.com/blog/what-is-an-ad-exchange. Accessed May 23, 2024.
[70] Titone T., ad tech explained, "Real-Time Bidding Explained – How do ad auctions work?" (August 22, 2021) https://adtechexplained.com/real-time-bidding-explained/. Accessed May 30, 2024.
[71] Flanagan J., adtaxi, "The Origins and Progression of Real-Time Bidding," (March 15, 2018) https://www.adtaxi.com/blog/origins-progression-real-time-bidding/. Accessed May 23, 2024.
[72] Flanagan J., adtaxi, "The Origins and Progression of Real-Time Bidding," (March 15, 2018) https://www.adtaxi.com/blog/origins-progression-real-time-bidding/. Accessed May 23, 2024.
[73] Bigabid, "Waterfall vs. Header Bidding, Everything you Need to Know," https://www.bigabid.com/waterfall-vs-header-bidding/. Accessed May 23, 2024.

that allowed calling multiple exchanges at the same time, which I explain in further detail in Section VIII.[74]

43. There are several different types of auctions, but the two most common types used by exchanges are variants of "first-price" and "second-price" auctions. In a first-price auction, the highest bidder wins if their bid is above the auction floor, and the bidder pays what they bid.[75] Figure 3 shows the two possible outcomes of a first-price auction. On the left, the advertiser Alice is the highest bidder, and their bid is greater than the floor value. Therefore, Alice wins and pays exactly what they bid. If the highest advertiser's bid is below the floor, there is no winner in the auction as shown in the bar chart on the right side.

44. In a second-price auction, the highest bidder also wins but pays the amount of the second-highest bid.[76] Figure 4 illustrates an example of a second-price auction. Suppose that advertisers Alice and Bob are the two highest bidding advertisers in an auction. If both Alice's bid and Bob's bid are above the floor, as shown in the leftmost bar chart, the higher bidder wins and pays the value of the second-highest bid. If the highest bid is above the floor, but the second-highest bid is below the floor, as shown in the middle figure, the highest bidding advertiser wins and pays the value of the floor. If both bids are below the floor, then neither advertiser wins, as shown in the rightmost bar chart.

[74] Bigabid, "Waterfall vs. Header Bidding, Everything you Need to Know," https://www.bigabid.com/waterfall-vs-header-bidding/. Accessed May 23, 2024.
[75] [redacted] Deposition, (April 26, 2024) at 249:25-251:7; Expert Report of Matthew Weinberg, June 7, 2024, para. 18 [*hereinafter* Weinberg Report].
[76] [redacted] Deposition, (April 26, 2024) at 249:25-251:7; [redacted] Deposition, (April 26, 2024) at 19:2-7; Weinberg Report, para. 18.

Figure 3: Two outcomes in a first-price auction where Advertiser Alice placed the highest bid in the auction

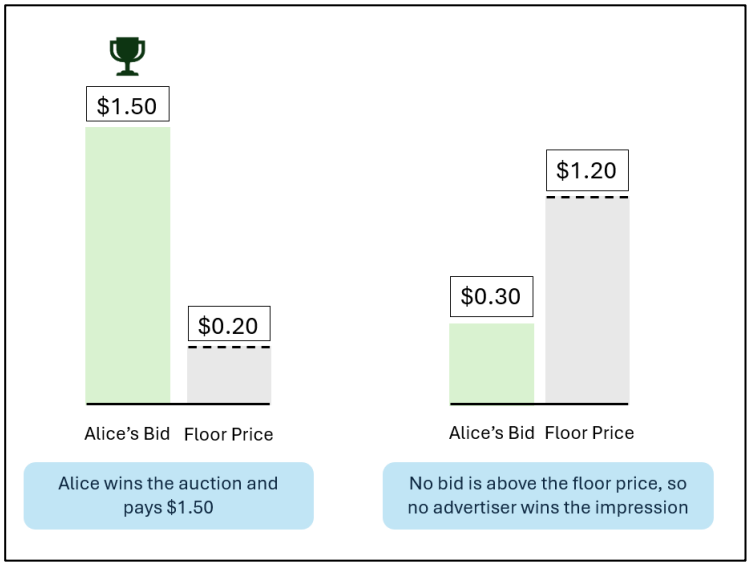
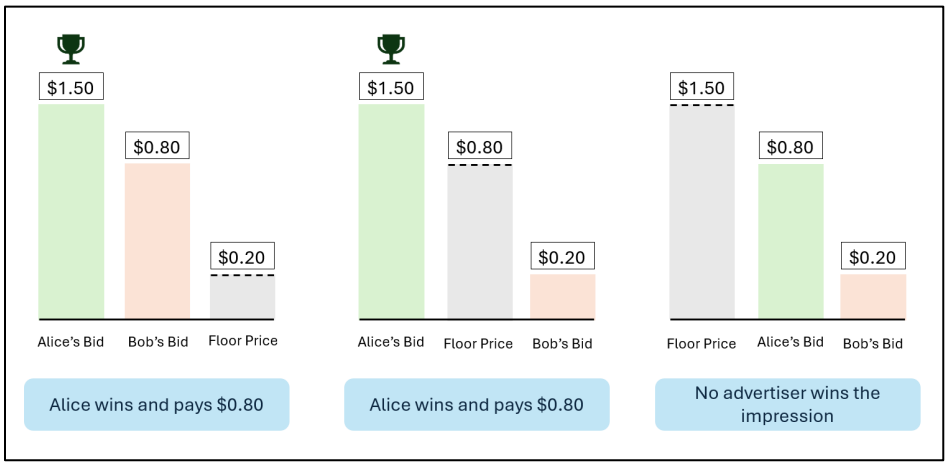


Figure 4: Three possible outcomes of a second-price auction. Bids placed by Advertisers A and B are the highest and second highest in the auction, respectively



45. Programmatic software that enables publishers to sell ad inventory across different advertiser tools are referred to as supply-side platforms or "SSPs." SSPs sell publisher inventory in various ways, including to ad networks, via direct deals, or through a real-time bidding auction, which is why "SSP" is occasionally used synonymously with ad exchange or ad server.

46. **Google Ad Exchange (AdX)** is Google's ad exchange platform and is currently marketed together with Google's ad server DFP as Google Ad Manager (GAM).[77] Publishers licensing DFP (and in a limited capacity, third-party ad servers) can have their ad inventory auctioned using AdX.[78] Google's buying tools, DV360 and Google Ads, as well as third-party buying tools that are authorized by Google, bid on ad slots in AdX.[79] Authorized third-party buying tools must be buying on behalf of multiple advertisers, meaning that an individual advertiser cannot bid into AdX.[80] To bid into AdX, third-party buyers build a real-time bidder, which is a piece of technology that can analyze all available advertisements and select one in real-time. The third-party real-time bidder connects to "Google servers to get a constant stream of 'callouts' or bid requests;"[81] the Google servers are known as "targeting servers" that are responsible for soliciting bids.[82] When an impression is auctioned in AdX, the real-time bidder is sent information about the user and the impression in the bid request, after which the real-time bidder may select an ad and a bid to send to AdX or place an empty bid if they do not choose to bid for that impression.[83]

47. As a general matter, AdX would take 20% of the clearing price as a fee for conducting the auction, though due to some publishers negotiating a lower rate and various Google programs that I will discuss in detail throughout the report, the revenue share could end up being more or less than 20% in some auctions.[84] While Google refers to the auction model that AdX operated until the fall of 2019 as second-price, the various programs implemented by Google impacted the

[77] Bellack J., Google Ad Manager, "Introducing Google Ad Manager," (June 27, 2018) https://blog.google/products/admanager/introducing-google-ad-manager/. Accessed May 23, 2024; Conversation with Professor Chandler, June 6, 2024.
[78] Google Ad Exchange is accessible to publishers using DFP via Google Ad Manager. Publishers using third party ad servers can access DFP via a tag called the "AdX Direct" tag which is described in detail in Section V.C.
[79] Google Ads and DV360 bid through the CAT2 mixer, authorized third-party bidders bid through the RTB mixer. This list is not exhaustive, for example buyers using GMob (Admob) can also bid in AdX but are out of scope. The details of the display ads serving stack are described in Section IV.D. Google internal document, "AViD Serving Architecture (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '697 (HCI).
[80] Google, "Authorized Buyers Overview," https://support.google.com/authorizedbuyers/answer/6138000. Accessed May 30, 2024.
[81] Google, "Authorized Buyers Overview," https://support.google.com/authorizedbuyers/answer/6138000. Accessed May 30, 2024.
[82] Google internal document, "Display Ad Serving: SellSide POV," (July 2022) GOOG-AT-MDL-012693796 at '824-827 (HCI).
[83] Google, "Authorized Buyers Overview," https://support.google.com/authorizedbuyers/answer/6138000. Accessed May 30, 2024.
[84] Google internal document, "AdX dynamic sell-side revenue share (DRS v1) – project description /Mini PRD," GOOG-AT-MDL-009013303 at '303 (HCI); [redacted] Deposition, (April 19, 2024) at 214:12-19.

way that these auctions were run such that they were not true second-price auctions.[85] For this reason, I refer to the AdX auction prior to 2019 as a "modified second-price auction." After 2019, AdX switched to a first-price model, but similarly, due to a number of Google programs that modified auction dynamics, I refer to it as a modified first-price auction.[86]

C. Ad buying tools: advertisers' tools for purchasing web display advertising

48. Advertisers use ad buying tools to, among other things, manage their ad campaigns and buy ad space in real-time.[87] As discussed previously, while advertisers can negotiate direct deals with publishers to show their ads on the publisher's website, they can also bid for publisher inventory as it becomes available using an automated ad buying tool.[88] To use these tools, advertisers upload their ads to the ad buying tool, set budgets, and indicate their desired targeting criteria.[89] For example, an advertiser that sells running shoes may indicate through their buying tool that they would like to target people who are interested in running or who are in the market for sports shoes. The ad buying tool connects with networks and exchanges whose inventory matches the advertiser's targeting criteria and uses the advertiser's budget and desirability of the ad slot (based on the targeting criteria) to determine an optimal bid. The tool then submits the ad and its corresponding bid to one or more ad networks and exchanges.[90]

49. Ad buying tools can offer varying levels of sophistication when it comes to targeting and campaign management and can service advertisers of different sizes; larger and more

[85] Google internal document, "AdX First Price Auction," GOOG-TEX-00841386 at '388 (HCI); Weinberg Report, Section 7.
[86] Google internal document, "AdX First Price Auction," GOOG-TEX-00841386 at '388 (HCI); Weinberg Report, Section 6.
[87] adjust, "What is a demand-side platform (DSP)?" https://www.adjust.com/glossary/demand-side-platform/. Accessed May 23, 2024. The term DSP is often used to describe buying tools for larger advertisers, when I describe buying tools here, I refer to DSPs as well as buying tools for small advertisers, such as Google Ads.
[88] Munro B., Publift, "What is Programmatic Direct," (April 8, 2024) https://www.publift.com/blog/what-is-programmatic-direct. Accessed May 23, 2024; adjust, "What is a demand-side platform (DSP)?" https://www.adjust.com/glossary/demand-side-platform/. Accessed May 23, 2024.
[89] adjust, "What is a demand-side platform (DSP)?" https://www.adjust.com/glossary/demand-side-platform/. Accessed May 23, 2024. This describes this functionality for DSPs, buying tools for small advertisers, like Google Ads, also have this functionality. Google Ads, "How to set up your first Google Ads campaign," https://ads.google.com/intl/en_us/home/how-it-works/. Accessed May 23, 2024.
[90] Sweeney M., clearcode, "What is a Demand-Side Platform (DSP) and How Does It Work?" (January 31, 2024). https://clearcode.cc/blog/demand-side-platform/. Accessed May 23, 2024. This describes the functionality for DSPs, buying tools for small advertisers like Google Ads also have this functionality. Google Ads Help, "About the Display Network ad auction," https://support.google.com/google-ads/answer/2996564. Accessed May 21, 2024.

sophisticated advertisers generally use different, more complex tools than smaller advertisers.[91] Many ad buying tools take a percentage of each winning bid placed by the tool.[92] Some buying tools may charge a flat monthly rate or charge for advanced data insights, campaign management services, or targeting capabilities.[93]

50. Platforms used by advertisers to buy ad slots from a variety of publishers and perform real-time targeting are often referred to as demand-side platforms or "DSPs." DSPs allow advertisers to buy from multiple ad sources and manage multiple sources of demand from one interface. DSPs place bids on behalf of advertisers based on targeting criteria set by advertisers.[94] DSPs mostly function as an advertiser ad buying tool.[95]

51. Ad buying tools generally offer different ways for advertisers to pay for their ads to be shown on a publisher platform. Two common ways are paying per view (CPM) and paying per click (CPC).[96] CPM stands for "cost-per-mille," and represents the cost for every thousand impressions received. CPC, which stands for "cost-per-click," is an alternative metric in which the cost is calculated per user click on the ad.[97] Unlike CPM, CPC is calculated on an individual basis, meaning that if an advertiser has a payment plan of $1.00 CPC, they will pay $1.00 for each click on their ad, as opposed to $1.00 CPM, where they will pay $1.00 for 1000 views, regardless of clicks.[98] The primary distinction between the two metrics lies in the payment structure. With CPM, advertisers pay the full campaign price regardless of performance – in other words, an advertiser must pay if the ad receives 1,000 impressions even if no one ever clicks on the ad.

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[91] For example, DV360 is suited for enterprises while Google Ads is suited for small businesses. Google, "Take control of your campaigns," https://marketingplatform.google.com/about/display-video-360/. Accessed May 30, 2024; Google, "Drive sales with Google Ads," https://ads.google.com/home/. Accessed May 23, 2024.
[92] Greenfield I., mntn, "Demand Side Platform (DSP): What Is It and How Does It Work?" https://mountain.com/blog/demand-side-platform/. Accessed May 23, 2024. In internal Google docs, Google Ads revenue share is listed as 14 or 15% and DV360's revenue share is listed as around 10%. Google internal document, "Ecosystem – margins, auction dynamics, supply path opt...," GOOG-NE-10730420 at '425 (HCI).
[93] Greenfield I., mntn, "Demand Side Platform (DSP): What Is It and How Does It Work?" https://mountain.com/blog/demand-side-platform/. Accessed May 23, 2024.
[94] Greenfield I., mntn, "Demand Side Platform (DSP): What Is It and How Does It Work?" https://mountain.com/blog/demand-side-platform/. Accessed May 23, 2024
[95] Conversation with Professor Chandler, June 6, 2024.
[96] Criteo, "What is the difference between CPC and CPM?" (April 12, 2017) https://www.criteo.com/blog/whats-difference-cpc-cpm/. Accessed May 23, 2024.
[97] Criteo, "What is the difference between CPC and CPM?" (April 12, 2017) https://www.criteo.com/blog/whats-difference-cpc-cpm/. Accessed May 23, 2024.
[98] Criteo, "What is the difference between CPC and CPM?" (April 12, 2017) https://www.criteo.com/blog/whats-difference-cpc-cpm/. Accessed May 23, 2024.

Conversely, with CPC, advertisers are charged only for actual clicks on the ad regardless of the total number of impressions the ad received.[99]

52. AdX uses CPM to set floors within the auction, and DFP publishers are often paid on a CPM basis.[100] Furthermore, AdX requires that all bids submitted to its auctions are in CPM.[101] Thus, if a buying tool has an option for buyers to pay per click or to select another metric, the buying tool must have a conversion algorithm to convert that metric to CPM for its bid to be accepted by AdX. For example, if an advertiser is willing to pay $1.00 for each click on its ad, and historical data shows that one out of every 10 users who view the ad clicks on it, the buying tool may decide to bid $0.10 CPM for the ad to ensure that the advertiser does not lose money on average.[102]

53. **Google Ads (formerly AdWords)** is Google's ad buying tool for small advertisers.[103] According to Google, this tool is appropriate for advertisers without sophisticated ad campaigns, as the tool is relatively simple to set up and does not have a minimum spending or ad volume requirement to create an account.[104] Along with display ads, Google Ads also allows advertisers to set up Google Search ad campaigns, which are ads that appear alongside search results on Google.com.[105] When creating a new display advertising campaign, Google Ads users indicate two key pieces of information: their targeting criteria and the campaign budget type.[106] For example, an advertiser may choose to target people who are "fans of sports and travel" and set up a manual

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[99] Criteo, "What is the difference between CPC and CPM?" (April 12, 2017) https://www.criteo.com/blog/whats-difference-cpc-cpm/. Accessed May 23, 2024.
[100] Unified pricing rule floors are set on a CPM basis, Google Ad Manager, "Unified First-Price Auction – Best practices," https://services.google.com/fh/files/misc/unified_first-price_auction_best_practices.pdf. Accessed May 23, 2024. RTB buyers must place bids in CPM. Google, "Introduction to real-time bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024.
[101] Metrics used for programmatic guaranteed and preferred deals can include CPD (cost-per-day), CPF (campaign total cost), or CPM. Google Ad Manager Help, "Programmatic Guaranteed vs. Preferred Deals," https://support.google.com/admanager/answer/7637485. Accessed May 23, 2024.
[102] This is a simplified version of conversions that ignores the publisher's revenue share and other factors that may be considered by conversation models. [redacted] Deposition, (April 19, 2024) at 125:15-23.
[103] Google Ads is often referred to in internal documents as "AdWords" or "Google Display Network" (GDN). Some documents refer to GDN as AdSense and Google Ads together, while others refer GDN as just Google Ads. [redacted] Deposition, (April 19, 2024) at 23:16-17; Google internal document, "Google Display Network Launch," GOOG-TEX-00820709 at '710 and '714 (HCI).
[104] Google, "3 questions businesses should ask when they get started with Google Ads," https://blog.google/outreach-initiatives/small-business/small-business-google-ads-tips/. Accessed May 23, 2024.
[105] Google Ads, "Be just a Google Search away," https://ads.google.com/intl/en_us/home/campaigns/search-ads/. Accessed May 23, 2024.
[106] Google Ads, "How to set up your first Google Ads campaign," https://ads.google.com/intl/en_us/home/how-it-works/. Accessed May 23, 2024.

CPC budget type and indicate they are willing to pay a maximum of $1.00 per click on their ad. Advertisers can also use Google Ads automated bidding budget campaign.[107] For example, in a "maximize clicks" automated bidding budget type, advertisers set an average daily budget and Google Ads tries to get as many clicks as possible within that budget.[108] Advertisers can optionally set a bid maximum for individual bids to have a little more control.[109] The advertiser's budget and budget type are used by the buying tools' bidding algorithms to determine when and how much to bid.[110]

54. Google Ads provides ads for AdSense publishers, places bids into AdX, and submits bids to third-party exchanges in a limited capacity through a program called AWBid, which is described in detail in Section IV.G**Error! Unknown switch argument.**.[111] Google Ads takes a [redacted]%[112] revenue share from each winning bid it places in AdX.[113] Google Ads is also used by advertisers to create Search ads on Google.com.[114]

55. **DV360** is Google's ad buying tool for larger and enterprise-size advertisers (*e.g.*, the minimum monthly spend on DV360 is reported to be around $50,000).[115] DV360 offers more

[107] Google Ads Help, "About bidding features in Display campaigns," https://support.google.com/google-ads/answer/2947304. Accessed May 23, 2024.
[108] Google Ads Help, "Maximize clicks: Definition," https://support.google.com/google-ads/answer/6336101. Accessed May 23, 2024.
[109] Google Ads Help, "Maximum CPC bid: Definition," https://support.google.com/google-ads/answer/6326. Accessed May 23, 2024.
[110] Google Ads Help, "Maximum clicks: Definition," https://support.google.com/google-ads/answer/6336101?hl=en. Accessed June 5, 2024
[111] Google internal document, "Ecosystem – margins, auction dynamics, supply path opt…," GOOG-NE-10730420 at '427 (HCI); Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '903 (HCI); [redacted] Deposition, (April 26, 2024) at 101:14-18.
[112] Some internal Google documents say [redacted] and some say [redacted] so this may have changed over time.
[113] Google internal document, "Ecosystem – margins, auction dynamics, supply path opt…," GOOG-NE-10730420 at '425 (HCI).
[114] Google Ads Help, "Create a Search campaign," https://support.google.com/google-ads/answer/9510373. Accessed May 23, 2024; Search ads are not within the scope of this report.
[115] Programmads, "Why use DV360 instead of Google Ads?" https://programmads.com/project/why-use-display-video-360-instead-of-google-ads/. Accessed May 23, 2024; Google does not publicly disclose pricing for DV360, but several online sources list $50,000 as the minimum monthly spend. Ganz E., ADCORE Blog, "What is DV360 and How to Start Advertising," (March 11, 2024) https://www.adcore.com/blog/what-is-dv360-and-how-to-start-advertising. Accessed May 23, 2024. The Google Marketing Platform page places DV360 under the "enterprise" tab. Google Marketing Platform, "Take control of your campaigns," https://marketingplatform.google.com/about/display-video-360/ Accessed May 23, 2024; DV360 used to be called "DoubleClick Bid Manager" (DBM) and is sometimes referred to internally at Google as "XBid". Internal documents often refer to DV360 using these terms. Display & Video 360 Help, "Introducing Google Marketing Platform," https://support.google.com/displayvideo/answer/9015629. Accessed June 4, 2024; [redacted] Deposition, (April 19, 2024) at 118:11-13.

advanced capabilities than Google Ads in targeting, ad placement, and reporting.[116] It offers all the targeting options available on Google Ads, along with advanced options that allow for more precise user targeting.[117] It bids into AdX and into third-party exchanges, therefore offering a broader range of ad inventory.[118, 119, 120] Additionally, DV360 has more advanced analytic capabilities and offers reporting options beyond the basic campaign analytics offered by Google Ads.[121] DV360 has more media formats, such as audio and native advertisements, and has the option for advertisers to set up direct deals with publishers along with the option of bidding in exchanges.[122] Overall, DV360 is designed for handling larger and more sophisticated advertising campaigns than Google Ads.

56. DV360 initially only offered CPM payment campaigns until Google introduced DV360 Pay-Per-Outcome (PPO) in September 2019, which gave DV360 advertisers the option to pay for outcomes, such as clicks or other metrics, similar to how payment works in Google Ads.[123] DV360 PPO is described in greater detail in Section IV.I.

IV. OVERVIEW OF HOW INFORMATION IS PASSED FROM ONE TOOL TO ANOTHER

57. This section discusses how information is passed from one ad stack tool to another. First, I provide an overview of the ad serving stack and information flow during the ad serving process, including descriptions of line items, ad tags, user data flows, and mixers. Then, I describe programs that enable Google's ad buying tools to bid into third-party exchanges, purchase directly

[116] Programmads, "Why use DV360 instead of Google Ads?" https://programmads.com/project/why-use-display-video-360-instead-of-google-ads/. Accessed May 23, 2024.
[117] Jain A., Tatvic, "What is the Difference between DV360 and Google Ads?" https://www.tatvic.com/blog/what-is-the-difference-between-dv360-and-google-ads/. Accessed May 23, 2024.
[118] Google, "Introducing Google Marketing Platform – Display & Video 360 Help," https://support.google.com/displayvideo/answer/9015629?hl=en. Accessed June 4, 2024.
[119] Display & Video 360 Help, "Managing exchanges," https://support.google.com/displayvideo/answer/9230278?hl=en. Accessed June 6, 2024.
[120] Display & Video 360 Help, "Supported display exchanges," https://support.google.com/displayvideo/table/3267029?hl=en. Accessed June 6, 2024.
[121] Jain A., Tatvic, "What is the Difference between DV360 and Google Ads?" https://www.tatvic.com/blog/what-is-the-difference-between-dv360-and-google-ads/. Accessed May 23, 2024.
[122] Native ads are ads that feel as though they are part of the page content, based on their style. Adjust, "What is native advertising," https://www.adjust.com/glossary/native-advertising/. Accessed May 23, 2024; Medium, "Google Ads vs. DV360: Which One is Better?" (March 20, 2024) https://medium.com/@contact_10971/google-ads-vs-dv360-which-one-is-better-8fbd3a883787. Accessed May 23, 2024.
[123] Google internal document, "Pay per Outcome in DBM," (February 10, 2018) GOOG-NE-13620081 at '081-083 (HCI).

from publishers, and purchase ads based on outcomes as opposed to views. Lastly, I describe how Google's ad serving functionality has changed over time and how it functions today.

A. Line items are set in GAM and contain information that defines available advertisements for a publisher's website

58. "Line items" are information fields set in DFP that contain ad information from direct deals with advertisers or ads received from an ad exchange or network.[124] Line items define how and where ads are intended for display on a website or application. For example, each line item from a direct deal contains details such as the number of times the advertiser wants an advertisement to be shown, negotiated cost for the campaign, campaign period, etc.[125] Each line item can only belong to one "order," which is a transaction between the publisher and a buyer.[126] There are different types of line items with varying levels of priority, which are represented by numeric values and help determine how line items compete against each other for an impression. A lower number assigned to a line item reflects its higher priority.[127]

59. Google groups line items into two categories: "guaranteed" (also known as "reservation")[128] and "non-guaranteed" (also known as "remnant")[129] line items. Guaranteed line items are contractually obligated to deliver a set number of impressions, while non-guaranteed line items are typically used to fill a site's unsold inventory. In other words, when a website does not have enough guaranteed line items to satisfy all available impressions, the remaining (remnant) inventory can be filled using non-guaranteed line items. Guaranteed line items have a higher priority and are therefore prioritized over non-guaranteed line items.

60. There are only two types of guaranteed line items: "Sponsorship" and "Standard." There are seven types of non-guaranteed line items: AdSense (or Ad Network); AdX (or Ad Exchange); Preferred Deals; Network; Bulk; Price Priority; and House. In addition to being booked directly by the publisher through the GAM interface, non-guaranteed line items can also represent third-

[124] Google Ad Manager Help, "About line items," https://support.google.com/admanager/answer/9405477. Accessed May 23, 2024.
[125] Google Ad Manager Help, "About line items," https://support.google.com/admanager/answer/9405477. Accessed May 23, 2024.
[126] Google Ad Manager Help, "Add new line items," https://support.google.com/admanager/answer/82236. Accessed May 23, 2024; Google Ad Manager Help, "Get started with ads in Google Ad Manager," https://support.google.com/admanager/answer/6027116. Accessed May 23, 2024.
[127] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[128] Google internal document, "Life of a Bid Request," GOOG-AT-MDL-004221745 at '763 (HCI).
[129] Google internal document, "Life of a Bid Request," GOOG-AT-MDL-004221745 at '763 (HCI).

party ad networks or exchanges.[130] More specifically, third-party ad exchanges can be represented as Price Priority line items, while third-party ad networks can be represented as either Price Priority or Network line items.[131] Therefore, when I discuss remnant line items or non-guaranteed line items throughout this report, I am also referring to line items corresponding to demand from third-party networks and exchanges. Table 1 below provides a detailed look at each of the line items of both guaranteed and non-guaranteed types.

Table 1: Types of Google Ad Manager Line Items

Line Item Category	Line Item Type	Priority	Description
Guaranteed	Sponsorship	4	Sponsorship line items have the highest priority and are served based on a defined percentage of impressions and a given campaign period. This line item type is typically used when a buyer wants to "take over" a webpage.[132]
	Standard	6 8 10	Standard line items are served based on a defined impression goal and campaign period.[133]
Non-guaranteed	AdSense	12	AdSense line items are targeted to specific inventory available to AdSense buyers.[134]
	AdX	12	AdX line items are targeted to specific inventory available to buyers bidding into AdX.[135]

[130] Google internal document, "RTB Insights," GOOG-AT-MDL-001793318 at '363-364 (HCI).
[131] Google internal document, "RTB Insights," GOOG-AT-MDL-001793318 at '363-364 (HCI). Occasionally, third-party exchanges and/or networks can be represented as Sponsorship or Standard line items. For example, Header Bidding buyers, who are third-party exchanges and/or networks that participate in an auction outside of AdX, can occasionally be represented in this way. Google internal document, "Header Bidding & AdX Positioning," (December 2, 2015) GOOG-AT-MDL-004284449 at '461 (CI).
[132] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279 Accessed May 23, 2024.
[133] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[134] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[135] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.

Line Item Category	Line Item Type	Priority	Description
	Preferred Deals	A "fixed value" that only loses to guaranteed line items.[136]	Preferred Deals give certain buyers priority tier inventory or can help sell unique inventory. Preferred Deal line items generally serve ahead of all line items except guaranteed line items.[137]
	Network	12	Network line items can be used to fulfill a defined percentage of remaining impressions not fulfilled by guaranteed line items.[138]
	Bulk	12	Bulk line items can be used to fill unsold inventory within a defined impression cap.[139]
	Price Priority	12	Price Priority line items can be used to fill unsold inventory with the highest paying line item available.[140]
	House	16	House line items are ads that promote products or services chosen by the publisher.[141] They typically do not generate any revenue,[142] and hence are only served when no remnant line items (Network, Bulk, Price Priority), AdX or Open Bidding

[136] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[137] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[138] Google Ad Manager Help, "Network line items," https://support.google.com/admanager/answer/171909. Accessed May 23, 2024; Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[139] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[140] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024.
[141] Google Ad Manager Help, "House line items," https://support.google.com/admanager/answer/79305. Accessed May 23, 2024.
[142] Google Ad Manager Help, "House line items," https://support.google.com/admanager/answer/79305. Accessed May 23, 2024.

Line Item Category	Line Item Type	Priority	Description
			(formerly known as Exchange Bidding) demand are available to serve.[143]

61. Figure 5 below shows an example set of line items for a hypothetical publisher called "PubNews."[144]

Figure 5: Example line items for a hypothetical publisher, PubNews[145]

Line Item Number	Type	Priority	Target	Start/End Date	Delivery Rate	Rate	Ad Unit	Targeting
LI 1	Sponsor	4	50 %	1/1 - 1/7	Evenly	$ 5.00 CPM	PubNews/Sports	"Gender" is "F"
LI 2	Standard	8	700,000 impressions	1/1- 1/7	Frontloaded	$ 7.00 CPM	PubNews/Sports PubNews/Gossip	
LI 3	AdX	12	-	1/1 - 12/31	-	-	PubNews/Sports PubNews/Gossip	
LI 4	Bulk	12	100,000 impressions	1/1 - 2/28	-	$ 12.00 CPM	PubNews/Gossip	"Gender" is "M"
LI 5	Price Priority	12	-	1/1 – 12/31	-	$10.00 CPM	PubNews/Gossip	"Gender" is "F"

62. In this example, PubNews is an online magazine with "Sports" and "Gossip" sections that each have one ad slot. Line item 1 is a Sponsorship line item, which indicates that PubNews has entered a deal with an advertiser to show the advertiser's ads for 50% of impressions on the "Sports" page. This ad is targeted at female users, and the deal is valid between January 1 and 7. Line item 2 is a Standard line item and represents a pre-negotiated deal to show 700,000 impressions of the advertiser's ad on either section of the PubNews page. The delivery rate is "frontloaded," meaning that more advertisements should be shown at the beginning of the negotiated period, January 1 through January 7. Line item 3 is an AdX line item and will run an auction in AdX. Line item 4 is a Bulk line item, which means that PubNews will fill up to 100,000 impressions with the advertiser's ad, but these are not guaranteed. Finally, line item 5 is a Price Priority type targeting female users. Line items 1, 2, 4, and 5 are negotiated directly between the publisher and the advertiser and entered into GAM. Their CPMs are therefore fixed. Line item 3

[143] Google Ad Manager Help, "Line item types and priorities," https://support.google.com/admanager/answer/177279. Accessed May 23, 2024; Open bidding, also known as "Exchange Bidding," is described in Section IX.
[144] Based on Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '722 (HCI).
[145] This example has been synthesized from an internal Google document. Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '722 (HCI).

contains the winning bid from the AdX auction, which runs in real-time as the user loads a webpage.

63. In this example, different line items may be selected as the winning ad for a particular ad slot on a page depending on a variety of factors.[146] This example intends to convey an overview of how line item selection works with Enhanced Dynamic Allocation, which is discussed in detail in Section VII. Consider a scenario where a female user, as indicated by targeting data, opened the webpage PubNews "Sports" on January 6.

1) If PubNews is behind schedule on delivering its promised 50% for line item 1, DFP will likely choose to show the ad associated with this line item because the negotiated period has almost concluded.

2) If PubNews is on track to meet the target in line items 1 and 2, one of the remnant line items may be shown to the user. In this example, line items 3, 4, and 5 all have the same priority level. However, line items 4 and 5 are for a different unit, the "Gossip" section, and line item 4 targets male users. Therefore, of the remnant line items, only line item 3 is eligible to serve. If the AdX auction returns an ad with a $10.00 CPM bid, which is higher than the floor, then that ad will be shown.

64. However, if a female user opens the "Gossip" section on January 10, all guaranteed line items have expired, and line item 4 is ineligible because of targeting. If AdX returns a bid of $6.00, it is beaten by line item 5 with a $10.00 CPM, and the ad from line item 5 will serve.

65. As another example, if a male user opens the "Gossip" section, line item 1 is ineligible based on targeting, and the ad for line item 2 may be shown to the user, depending on the delivery schedule. If line item 2 is on track to deliver, DFP may choose to serve a remnant line item. Line items 3 and 4 are eligible based on targeting. If the AdX auction returns a bid with a CPM of $8.00, line item 4 will be selected since it has a higher CPM.

66. Other auction outcomes are possible depending on user targeting and date, delivery schedules of guaranteed line items, and the bid value returned by the AdX auction.

[146] For purposes of illustration, this example abstracts away auction mechanics such as EDA or unified floors and focusing on the overall goal of line item selection.

B. Ad tags are used by publisher websites to communicate with the publisher's ad server

67. The process of serving an advertisement begins with an "ad tag" on a publisher's website. An ad tag is a piece of code that is embedded on a publisher's website and allows the website to communicate with an ad server.[147] The ad tag runs when a user opens the website on a browser. The most common way publishers create ad tags is by registering their website on an ad server, which in turn generates an ad tag for the publisher to place on their website.[148] The ad tag handles the beginning and the end of the ad serving process by sending out a request for ads to the ad server, receiving the response, and sending the winning advertisement to the browser.[149]

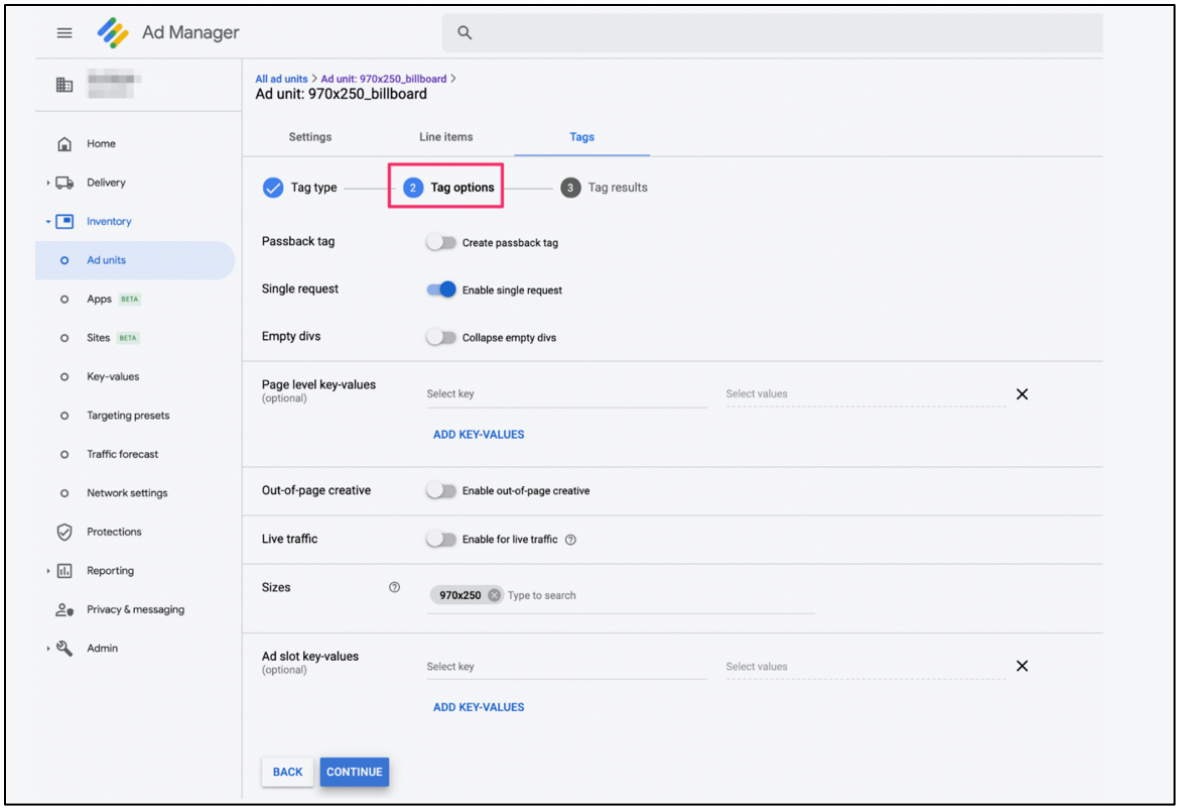
68. Tags that are used to call the DFP ad server are currently part of the Google Publisher Tag or "GPT" ad tag library.[150] GPT tags are written in the JavaScript programming language and perform three general tasks: (1) allow publishers to create ad slots, (2) send an ad request to DFP, and (3) receive and process DFP's response to render an ad on the page.[151] GPT tags were introduced in October 2011 to replace DoubleClick DFP tags.[152] GPT tags came with a number of additional features, such as asynchronous tags, which allows the ad to load independently of the rest of the publisher's content (*i.e.*, if an ad fails to load, it will not slow down the loading process of the entire webpage) and single request architecture (SRA), which allows sending all ad slots available on a page in a single request to DFP.[153]

69. When publishers generate a GPT tag, they can include several specifications for their ad slot that determine how the ad renders and how the DFP request is sent. Figure 6 shows the interface that a publisher sees and the options that are available when setting up a GPT tag.[154] For

[147] Novatska K., Cepom, "What is an Ad Tag and How to Generate It," (March 11, 2020) https://epom.com/blog/ad-server/what-is-an-ad-tag. Accessed May 23, 2024.
[148] Novatska K., Cepom, "What is an Ad Tag and How to Generate It," (March 11, 2020) https://epom.com/blog/ad-server/what-is-an-ad-tag. Accessed May 23, 2024.
[149] Novatska K., Cepom, "What is an Ad Tag and How to Generate It," (March 11, 2020) https://epom.com/blog/ad-server/what-is-an-ad-tag. Accessed May 23, 2024.
[150] Google, "Get Started with Google Publisher Tag," https://developers.google.com/publisher-tag/guides/get-started. Accessed May 23, 2024.
[151] Google internal document, "Google Publisher Tag," GOOG-AT-MDL-B-005090414 at '414 (HCI).
[152] Google, "Introducing the next generation of the DFP ad tag," (October 25, 2011) https://doubleclick-publishers.googleblog.com/2011/10/introducing-next-generation-of-dfp-ad.html. Accessed June 4, 2024.
[153] Google Ad Manager Help, "Overview of Google Publisher Tag," https://support.google.com/admanager/answer/181073. Accessed May 30, 2024.
[154] Google Ad Manager Help, "Generate ad tags," https://support.google.com/admanager/answer/177207. Accessed May 23, 2024.

example, publishers can indicate the ad sizes that the slot can accept and whether the ad slot should "collapse" if an ad is not served.[155]

Figure 6: The user interface for configuring a GPT tag[156]



70. Google also provides AdX tags, which allow publishers to send ad requests directly to the AdX auction without calling DFP.[157] Using AdX tags, publishers with non-Google ad servers can auction their slots in AdX.[158] AdX tags are sometimes referred to as "adsbygoogle" tags, which also service AdSense traffic.[159]

[155] Google Ad Manager Help, "Generate ad tags," https://support.google.com/admanager/answer/177207. Accessed May 23, 2024.
[156] Zaiceva A., "Google Publisher Tag (GPT): A Complete Beginner's Guide," (July 2, 2021) https://setupad.com/blog/google-gpt/. Accessed May 23, 2024.
[157] Google internal document, "AdX Direct Review," (February 11, 2020) GOOG-DOJ-27799214 at '215 (CI).
[158] Google internal document, "AdX Direct Review," (February 11, 2020) GOOG-DOJ-27799214 at '215 (CI).
[159] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '945 (HCI).

C. Google retrieves user information from cookies and publisher-provided data, and uses it to identify users and target ads

71. A user is identified to the publisher's ad server through an ID, which can come from a variety of sources including cookies, as well as publisher-provided information.[160] Cookies are text files with pieces of data about a user and can be used to store user information, personalize the user's experience, and track user data over time.[161] As one example, cookies can be used to remember the username and password of a user for a website, eliminating the need for users to remember login information. They can also be used to collect information about a user and personalize their experience, such as providing ads based on previously viewed products.[162] First-party cookies are created by the website owner (*i.e.*, the publisher) and stored directly on the website visited by the user. For example, first-party cookies are used if a website stores login information for users on that website. Third-party cookies are cookies from a different domain than the one visited by a user.[163] They are often used by ad servers to track user behavior across several websites. For example, if a user browses new sneakers on Amazon, they may get an ad for sneakers on a different website because of third-party cookies.[164] Many popular browsers have already taken steps to limit or remove third-party cookies.[165,166] Google Chrome, the browser developed by Google, has announced plans to phase out third-party cookies, with the aim of completely removing them for all users by early 2025.[167] I understand that while publishers will have access to some of the data that Google collects, publishers do not have access to all of the

[160] Google internal document, "DRX Identity 101," (March 2018) GOOG-AT-MDL-001963813 at '816 (HCI).
[161] Kaspersky, "What are Cookies?" https://usa.kaspersky.com/resource-center/definitions/cookies. Accessed May 23, 2024.
[162] Kaspersky, "What are Cookies?" https://usa.kaspersky.com/resource-center/definitions/cookies. Accessed May 23, 2024.
[163] Kaspersky, "What are Cookies?" https://usa.kaspersky.com/resource-center/definitions/cookies. Accessed May 23, 2024.
[164] Kaspersky, "What are Cookies?" https://usa.kaspersky.com/resource-center/definitions/cookies. Accessed May 23, 2024.
[165] Mills, C., Mozilla, "Saying goodbye to third-party cookies in 2024," (December 7, 2023) https://developer.mozilla.org/en-US/blog/goodbye-third-party-cookies/. Accessed May 24, 2024.
[166] Microsoft Edge Team, Microsoft Edge Blog, "New Privacy-Preserving Ads API coming to Microsoft Edge" (March 5, 2024) https://blogs.windows.com/msedgedev/2024/03/05/new-privacy-preserving-ads-api/. Accessed June 6, 2024.
[167] Google internal document, "Google Ad Manager Audience 101," (July 13, 2020) GOOG-AT-MDL-002011973 at '982 (HCI); Privacy Sandbox, "Prepare for third-party cookie restrictions," https://developers.google.com/privacy-sandbox/3pcd. Accessed May 21, 2024.

data that Google collects.[168] In particular, prior to Google's migration to a modified first-price auction, buyers were capable of opting out of Google disseminating their data.[169]

72. Google's third-party cookies provide two types of user IDs: [redacted].[170] In the absence of third-party cookies, Google can use [redacted] or [redacted] to identify users. [redacted] are cookies placed by Google on a publisher's website that function similarly to first-party cookies in the sense that they are not used to track a user across websites.[171] [redacted] are limited in their capabilities and cannot be used for ad personalization.[172] [redacted].[173] Google's stated order of preference for user identification is [redacted].[174]

73. [redacted].[175] However, in 2016 in a project internally called Narnia 2.0, Google introduced the ability for users to opt into ad personalization based on their [redacted].[176] For users that do opt-in, [redacted].[177]

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[168] [redacted] Deposition, (April 19, 2024) at 33:14-35:18.
[169] [redacted] Deposition, (April 19, 2024) at 35:2-18.
[170] Google internal document, "DRX Identity 101," (March 2018) GOOG-AT-MDL-001963813 at '816-817 (HCI); Google internal document, "Narnia 2 Gaia Keyed Serving End State Design (Tinman)," (June 12, 2017) GOOG-AT-MDL-016354429 at '429, '438. (CI); [redacted] Deposition, (May 23, 2024) at 220:8-222:9.
[171] Google refers to GFP cookies as first-party cookies, see Google internal document, "DRX Identity 101," (March 2018) GOOG-AT-MDL-001963813 at '816 (HCI). However, since they are placed by Google and not the publisher, they are not strictly first-party, but function similarly in the sense that they are not used to identify a user across different websites.
[172] Google internal document, "Project Samoas: Publisher's 1P Cookies/Ids Strategy," (January 2020) GOOG-AT-MDL-001418931 at '943 (HCI).
[173] Google internal document, "Project Samoas: Publisher's 1P Cookies/Ids Strategy," (January 2020) GOOG-AT-MDL-001418931 at '943 (HCI).
[174] Google internal document, "GAM and AdSense Monitoring for User IDs," (May 21, 2020) GOOG-AT-MDL-001418741 at '743 (HCI).
[175] Google internal document, [redacted] (June 12, 2017) GOOG-AT-MDL-016354429 at '430, '438. (CI).
[176] Google internal document, [redacted] (June 12, 2017) GOOG-AT-MDL-016354429 at '429, '436. (CI).
[177] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-007275806 at '810 (HCI).

74. Figure 7 is from an internal Google document and shows the targeting capabilities of Google Ads and DV360 before and after [redacted]

Figure 7: Additional capabilities provided by [redacted]

75. [redacted]

[178] Google internal document, "Narnia2 Overview 2016-12-14," (December 14, 2016) GOOG-AT-MDL-007418936 at '978 (HCI).
[179] Google internal document, "Narnia2 Overview 2016-12-14," (December 14, 2016) GOOG-AT-MDL-007418936 at '978 (HCI).
[180] Google internal document, [redacted] (June 12, 2017) GOOG-AT-MDL-016354429 at '440. (CI); [redacted] Deposition, (May 23, 2024) at 220:8-222:9.

[redacted]

76. [redacted]

77. PPID stands for "publisher provided identifiers" and is an option publishers can opt into within GAM to channel their first-party user data into Google's programmatic demand. PPIDs are user IDs collected by publishers and are intended to be meaningless to Google outside of uniquely identifying a user, which means that any information the publisher has about a user based on their ID is not communicated to Google with the PPID.[184] Google states that PPIDs passed to DFP should be encrypted and publishers must offer users the option to opt out of ad personalization, in which case the publisher should stop sending the PPID in the ad request. Google encourages publishers to adopt PPID as browsers, including Chrome, phase out third-party cookies.[185]

78. Google's data storage server, [redacted]

[181] Google internal document, [redacted] (June 12, 2017) GOOG-AT-MDL-016354429 at '440. (CI).
[182] Google internal document, "Narnia2 Overview 2016-12-14," (December 14, 2016) GOOG-AT-MDL-007418936 at '978 (HCI).
[183] Google internal document, "Project Samoas: Publisher's 1P Cookies/Ids Strategy," (January 2020) GOOG-AT-MDL-001418931 at ''934, '943 (HCI).
[184] Google Ad Manager Help, "About publisher provided identifiers," https://support.google.com/admanager/answer/2880055. Accessed May 23, 2024.
[185] Google Ad Manager Help, "About publisher provided identifiers," https://support.google.com/admanager/answer/2880055. Accessed May 23, 2024.
[186] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-007275806 at '807 (HCI).
[187] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-007275806 at '807 (HCI).
[188] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-007275806 at '807 (HCI).

[redacted]

D. Overview of the ad serving stack

79. As I previously described in Section IV.B, when a user visits a website with a GPT tag, the GPT tag composes an ad request for the publisher's ad server. The ad request contains information about the publisher, the ad slot, and the user.[192] An ad request may contain many parameters that can convey information about the publisher.[193] These parameters contain various pieces of information including: (1) inventory unit (for example, which section of an online newspaper the ad slot is in), (2) the ad slot information, such as its size and the format of the ad, (3) consent signals, which are mostly user privacy consent signals, (4) identity signals, such as user cookie IDs, (5) targeting information, for example the publisher indicating that this user is a regular viewer of the sport section of their newspaper, (6) spam signals, which are used to decide if the ad

[189] [redacted] oogle internal document, [redacted] (March 1, 2015) GOOG-AT-MDL-B-003983972 at '972-973 (CI); Google internal document, "ICM Narnia 2.0 Overview," (September 1, 2016) GOOG-DOJ-AT-02309120 at '121-122 (HCI); Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-007275806 at '807 (HCI).

[190] Search Ads 360 Help, "Set up remarketing lists for search ads," https://support.google.com/searchads/answer/7196986?hl=en. Accessed June 7, 2024; Google for Developers, "Cookie Matching | Real-time Bidding," https://developers.google.com/authorized-buyers/rtb/cookie-guide. Accessed June 7, 2024.

[191] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-007275806 at '807 (HCI).

[192] Google internal document, "Publisher request and response," (2017) GOOG-AT-MDL-001409774 at '795 (CI).

[193] Google internal document, "Publisher request and response," 2017) GOOG-AT-MDL-001409774 at '785 (CI).

request represents a real user, and (7) experiment information, which informs DFP if the impression is part of an experiment on a portion of traffic run by Google.[194]

80. Figure 8 shows an example of the beginning of an ad request URL sent from the user's browser to DFP. The ad request URL begins with "https://googleads.g.doubleclick.net/pagead/ads?" which indicates the domain from which GPT is loaded, followed by key-value pairs that communicate information to DFP. For example, "gdfp_req=1" is a standard value sent to indicate that this is an ad request from a GPT tag; "cookie = 7fh…" contains the user's GFP cookie ID; and "url=https://someurl.com" indicates the page URL.[195]

Figure 8: An example of an ad request URL sent from the user"s browser to DFP[196]

https://googleads.g.doubleclick.net/pagead/ads?gdfp_req=1&pvsid=453067787415724&impl=fifs&cookie=7fhdnekg9sh…1u2i39rhfna&u_tz=-240&ecs=20200911&url=https://someurl.com&…

81. [redacted]

[194] [redacted] Deposition, (April 19, 2024) at 82:2-87:23; Google internal document, "Publisher request and response," 2017) GOOG-AT-MDL-001409774 at '785 (CI); Google internal document, "Display Ad Serving: SellSide POV," (July 2022) GOOG-AT-MDL-012693796 at '813 (HCI).
[195] Google internal document, "Sample Value for Ad Request," GOOG-AT-MDL-B-007919337 at '337-339 (HCI); Google internal document, "Publisher request and response," (2017) GOOG-AT-MDL-001409774 at '785 (CI).
[196] Sample ad request URL based on Google internal document, "Sample Value for Ad Request," GOOG-AT-MDL-B-007919337 at '337-339 (HCI); Google internal document, "Publisher request and response," (2017) GOOG-AT-MDL-001409774 at '785 (CI).
[197] Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '697 (HCI); [redacted] Deposition, (April 19, 2024) at 79:10-24.
[198] Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '696 (HCI); [redacted] Deposition, (April 19, 2024) at 88:5-15; [redacted] Deposition, (April 19, 2024) at 90:14-16; [redacted] Deposition, (April 19, 2024) at 91:4-93:5.
[199] Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '695-697 (HCI); [redacted] Deposition, (April 19, 2024) at 90:17-91:3.

[redacted]

82. [redacted]

83. [redacted]

[200] Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '697 (HCI).
[201] Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '697 (HCI); [redacted] Deposition, (April 19, 2024) at 91:25-92:9; [redacted] Deposition, (April 19, 2024) at 95:13-102:11; [redacted] Deposition, (April 19, 2024) at 117:9-12.
[202] Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '696 (HCI).
[203] Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '696 (HCI).
[204] Logs are "checkpoints" in code that record information specific by the developer. They are used to track what is happening in the codebase and locate sources of errors. Google internal document, "Life of a query & Auction Overview," GOOG-AT-MDL-002295716 at '726 (HCI); Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-019603579 at '582 (HCI).
[205] Google internal document, "Display Ads: Unified Identity Service (UIS)," GOOG-AT-MDL-007400353 at '359 (HCI).
[206] Encryption is a way of encoding data so that unauthorized parties can't read it. Authorized parties have a decryption key that allows them to unencrypt the data. Google internal document, "Display Ads: Unified Identity Service (UIS)," GOOG-AT-MDL-007400353 at '366 (HCI).
[207] Google internal document, "Display Ads: Unified Identity Service (UIS)," GOOG-AT-MDL-007400353 at '366 (HCI).
[208] Google internal document, "Display Ads: Unified Identity Service (UIS)," GOOG-AT-MDL-007400353 at '362 (HCI).

[redacted]

E. Overview of mixers within Google's ad serving stack

84. This section provides an overview of the "mixers"[218] within AdX and DFP that are responsible for collecting ads from different sources and sending them to the auction.[219] [redacted]

[209] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-019603579 at '582 (HCI).
[210] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-007275806 at '809 (HCI).
[211] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-019603579 at '582 (HCI).
[212] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-019603579 at '582 (HCI).
[213] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-019603579 at '582 (HCI).
[214] RTB may have access to Google generated user data for frequency capping (making sure a user doesn't see an ad too many times). Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-019603579 at '583 (HCI).
[215] Google internal document, "Google Ad Manager Product Overview," (October 1, 2021) GOOG-AT-MDL-006138947 at '964 (CI).
[216] Google internal document, "Detailed Design for Narnia2 AFC Serving Stack," GOOG-AT-MDL-019603579 at '583 (HCI).
[217] Google internal document, "Display Ads: Unified Identity Service (UIS)," GOOG-AT-MDL-007400353 at '362 (HCI).
[218] Mixers are also called "targeting servers," Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '696 (HCI).
[219] Google internal document, "DRX Overview," (August 2019) GOOG-TEX-00856580 at '597 (HCI).

[redacted] Figure 9 provides an overview of the mixers bidding into the AdX auction.[222]

Figure 9: Overview of mixers that bid into the Supermixer[223]

[redacted]

85. [redacted].[224] When signing up for RTB in AdX, buyers indicate their pre-targeting criteria, such as language, geographical region, and the requests per second their system can receive.[225] For

[220] Google internal document, "Display Ad Serving: Sellside POV," (July 2022) GOOG-AT-MDL-012693796 at '828 (HCI).
[221] [redacted] Deposition, (April 19, 2024) at 95:13-102:11.
[222] Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '695 (HCI).
[223] This graphic is not meant to be comprehensive and excludes mixers that are out of the scope for this [redacted]. Google internal document, "AViD Serving Architecture 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '695 (HCI).
[224] [redacted]; Google, "Introduction to real-time-bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024; [redacted] Deposition, (April 19, 2024) at 120:23-121:4; Google document, "Display Ad Serving: Sellside POV," (July 2022) GOOG-AT-MDL-012693796 at '833 (HCI).
[225] Google, "Introduction to real-time-bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024.

example, a buyer may indicate that they would like to receive requests for all impressions served in English in New York. If an impression becomes available that fits the pre-targeting criteria, and the request limit has not been exceeded, the third-party buying tool is invited to place a bid via an external API.[226] The third-party buying tools receive a request that contains:[227]

1) The HTTP header with the referrer URL.[228]

2) Targeting information (*e.g.*, language, geographical region, size, etc.).

3) The truncated IP address of the user.[229]

4) The encrypted user cookie ID.[230]

5) Publisher ad restrictions, such as restricted advertisers or ad types, which are specified by the publisher through the DFP interface. Note that third-party buying tools can still occasionally output an ad that gets blocked.[231]

86. The third-party buying tool analyzes the request and adds additional targeting information it has available. For example, the third-party buying tool may have its own database of targeting information for different websites. The third-party buying tool invokes its bidding algorithm to determine an optimal bid to send to AdX if it decides a suitable advertisement is

[226] Google, "Introduction to real-time-bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024; Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '326 (CI); An API is a way that two software applications can "talk" to each other. It is an interface for software that can be thought of as a connection point or entry point to access a piece of software programmatically.
[227] Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '325 (CI).
[228] This informs the buying tool of the publisher website. HTTP headers contain metadata about the HTTP request. Postman, "What are HTTP headers," (July 11, 2023) https://blog.postman.com/what-are-http-headers/. Accessed May 23, 2024; Google, "Introduction to real-time-bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024.
[229] An IP address is a unique address that identifies a device on the internet or a local network. Kaspersky, "What is an IP Address – Definition and Explanation," https://usa.kaspersky.com/resource-center/definitions/what-is-an-ip-address. Accessed May 23, 2024; Google, "Introduction to real-time-bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024
[230] Cookies are text files with small pieces of data that are used to identify your computer as you use a network. Kaspersky, "What are Cookies?" https://usa.kaspersky.com/resource-center/definitions/cookies. Accessed May 23, 2024; Google, "Introduction to real-time-bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024.
[231] Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '327 (CI); Google, "Introduction to real-time-bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024.

available.[232] The response the third-party buying tool sends contains the CPM value of the bid and the creative redirect or a Google-hosted creative ID, which allows Google to locate the advertisement to place if the bid wins the final auction.[233]

F. Overview of the [redacted]

87. [redacted]

[232] Google, "Introduction to real-time-bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024.
[233] Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '327 (CI); Google, "Introduction to real-time-bidding (RTB)," https://support.google.com/authorizedbuyers/answer/6136272. Accessed May 23, 2024.
[234] Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '907 (HCI); Google internal document, "go/demand-product-design-doc," (January 15, 2018) GOOG-DOJ-14609574 at '578 (HCI).
[235] Google document, "go/demand-product-design-doc," (January 15, 2018) GOOG-DOJ-14609574 at '578 (HCI); Google document, "AViD Serving Infrastructure 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '701 (HCI)
[236] Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '903 (HCI); Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '331 (CI).
[237] Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '331 (CI).
[238] Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '327 (CI).
[239] Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '331 (CI).
[240] Google internal document, "Life of a query & Auction Overview," GOOG-AT-MDL-002295716 at '727 (HCI).

[redacted]

88. [redacted]

89. [redacted] ran a modified second-price auction until 2021 and a hybrid first and second-price auction after 2021 due to the auction type changes within AdX.[247] As previously mentioned in Section III.B, until 2019, AdX ran a second-price-style auction. In 2019, AdX switched to a first-

[241] [redacted]

[242] DV360 was previously known as DBM and internally at Google referred to as XBid.

[243] Schonfeld E., techcrunch, "Google Confirms Invite Media Acquisition, Brings Bidding to Display Ads," (June 3, 2010) https://techcrunch.com/2010/06/03/google-confirms-invite-media/. Accessed May 23, 2024; Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '334 (CI).

[244] Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '334 (CI); Google internal document, "Introduction to Mixers & SkyRay in AdX," (July 2016) GOOG-AT-MDL-B-005080323 at '336 (CI).

[245] In addition to Project SkyRay, Google had several other projects to unify its products. These projects include Project CroNut, Project Amalgam, Project Cramalgam, and Project CroRay. Project CroNut is the unification of DCM and DBM (DV360) products. DoubleClick Campaign Manager (DCM), also known as Campaign Manager 360 and XFA, is a web-based ad management system for advertisers and agencies. Project Amalgam is the unification of Google Ads and Search Ads 360. Search Ads 360 is a tool used by large advertisers to manage search ads. Project Cramalgam is the unification of Project Amalgam and Project CroNut. Project CroRay is the unification of Project CroNut and Project SkyRay. Google internal document, "Cramalgam ACM," (February 2019) GOOG-NE-03632946 at '956 and '962 (HCI); Campaign Manager 360 Help, "Overview of Campaign Manager 360," https://support.google.com/campaignmanager/answer/2709362. Accessed June 6, 2024; Google internal document, "Cramalgam Discussion," (February 2019) GOOG-NE-02345285 at '287 (HCI); Google internal document, "Cramalgam Proposal (draft)," GOOG-NE-02643371 at '371 (HCI); Google internal document, "Supermixer," (January 2020) GOOG-AT-MDL-001421306 at '349 (HCI).

[246] Google internal document, "Pay per Outcome in DBM," (February 10, 2018) GOOG-NE-13620081 at '085 (HCI).

[247] Google internal document, "Cat2 First Price Auction," GOOG-AT-MDL-018531517 at '519 (HCI).

price-style auction model.[248] [redacted]

G. AWBid is a program through which Google Ads bid into third-party exchanges in a limited capacity

90. CAT2 places Google Ads bids in third-party exchanges in a limited capacity through a program called AWBid.[253] AWBid was introduced in 2015 and originally was used only to bid for remarketing ads.[254] Remarketing ads target users that already interacted with an ad for that product and are thus more likely to purchase the product.[255] AWBid also places bids on Project Yavin, which is described in detail in Section IV.H, meaning it places bids directly into publisher ad servers.[256] In late 2018 and early 2019, AWBid was expanded to a broader range of targeting types.[257]

91. [redacted]

[248] Bigler J., "Rolling out first price auctions to Google Ad Manager Partners," (September 5, 2019) https://blog.google/products/admanager/rolling-out-first-price-auctions-google-ad-manager-partners/. Accessed May 23, 2024; Zaiceva A., "First-Price vs. Second-Price Auction | Difference Explained," (April 22, 2021) https://setupad.com/blog/first-price-vs-second-price-auction/. Accessed January 31, 2024.
[249] Google internal document, "Bidding Optimization for TaskAds & Survey," GOOG-DOJ-AT-02246549 at '553 (HCI); Google internal document, "CAT2 1P," (September 29, 2021) GOOG-AT-MDL-001132667 at '669 (HCI).
[250] Google internal document, "CAT2 First Price Auction," GOOG-AT-MDL-018531517 at '519 (HCI).
[251] See Appendix C Section B.16 for confirmation based on my analysis of Google's source code on the [redacted]
[252] See Appendix C Section B.19 for confirmation based on my analysis of Google's source code on Bernanke implementation in 2023.
[253] Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '903 (HCI).
[254] Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '903 (HCI); Google internal document, "AWBid," (November 2019) GOOG-NE-13614574 at '586 (HCI); Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '903 (HCI).
[255] Remarketing is the process of advertising to users that have already expressed interest in one's content, for example already visited the advertiser's website, but have not taken action, such as purchase the product that is being advertised. Cheikha E., Outbrain, "The Remarketing Guide for Dummies," (2023) https://www.outbrain.com/blog/remarketing-guide/. Accessed May 23, 2024.
[256] Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '903 (HCI).
[257] Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '903 (HCI). The targeting types are listed as "topic, in-market, affinity, ICM vertical and CIA/CIM targeting types."
[258] Google internal document, "AWBid Type2 Serving," (November 2015) GOOG-AT-MDL-016353371 at '371 (CI).

[redacted]

H. Project "Yavin" is a program through which Google Ads and DV360 are able to buy directly from publishers

92. Google introduced Project "Yavin" in early 2018[263] as a way for DV360 and Google Ads to buy directly from publishers' ad servers.[264] Instead of bidding through AdX, with Yavin, Google Ads and DV360 offer a bid for an impression directly to the publisher's ad server and the publisher can accept or decline.[265] Yavin is invite-only and is intended for "sophisticated publishers."[266]

93. Yavin operates using OpenRTB, which is a technology that facilitates real-time bidding, [redacted].[267] [redacted].[268] [redacted]

[259] Google internal document, "AWBid Type2 Serving," (November 2015) GOOG-AT-MDL-016353371 at '372 (CI).
[260] Google internal document, "AWBid Type2 Serving," (November 2015) GOOG-AT-MDL-016353371 at '373 (CI).
[261] Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '907 (HCI).
[262] Google internal document, "AWBid Overview," GOOG-DOJ-14298902 at '907 (HCI). A "creative" is another term for an ad and includes the media file (*e.g.*, image or video) to display. Google, "What are creatives?" https://support.google.com/admanager/answer/3185155?hl=en. Accessed June 7, 2024.
[263] [redacted] Deposition, (April 23, 2024) at 58:25-59:14; Google internal document, "Sellside Launch Doc: Demand Product," GOOG-AT-MDL-003991554 at '554 (CI) see "Links" section which has Ariane Launch code;
Google internal workbook, " ArianeDownload...," GOOG-AT-MDL-018219666 at Row 291 shows corresponding Ariane Launch code with launch date "Feb 1, 2018" and status "Launched." (HCI)
[264] Google proposed launching Yavin for AdX RTB demand, therefore making Yavin serving accessible to third-party buyers in AdX. Google internal document, "AdX Demand on Yavin," (December 8, 2017) GOOG-NE-12065295 at '296 (HCI); Google internal document, "Demand Product (Project Yavin)," (January 15, 2018) GOOG-AT-MDL-009754910 at '913 (HCI); Google internal document, "Roadmap for AdX demand on Yavin," (May 9, 2019) GOOG-DOJ-AT-02148683 at '683 (HCI).
[265] Google internal document, "eBay/Google," (December 2017) GOOG-DOJ-27712490 at '493 (CI).
[266] Google internal document, "eBay/Google," (December 2017) GOOG-DOJ-27712490 at '493 (CI).
[267] Google internal document, "Demand Product (Project Yavin)," (January 15, 2018) GOOG-AT-MDL-009754910 at '913 (HCI).
[268] Google internal document, "Demand product for dummies," (February 2018) GOOG-AT-MDL-003109989 at '000 (HCI).

[redacted] Bids placed via Yavin are first-price, meaning that if the bid is accepted, the advertiser will pay the value of the bid.[270] [redacted].[271]

94. Although Yavin enabled Google buying tools to buy directly from publishers' own ad servers, it was not widely used by publishers. Publishers had to enter a contract with Google to use Yavin and the program required "custom integrations between Google and each customer's ad server[.]" As of April 2024, since Yavin was introduced in 2018, I understand that only [redacted] publishers had signed Yavin contracts: [redacted]; the latter [redacted] publishers were not based in the United States.[272] Each of the [redacted] publishers' Yavin integrations are no longer live and running.[273]

I. DV360 PPO is a program through which DV360 advertisers can pay for outcomes, such as clicks, instead of views

95. As previously mentioned, in 2019 DV360 began offering the option for their advertisers to "pay-per-outcome" (PPO), similarly to payment options offered in Google Ads.[274] Instead of paying per impression, advertisers could choose to pay per specific outcomes related to their campaign goals – in other words, they can choose to pay only if their target user performs a desired action. For example, advertisers can pay for clicks, conversions or installs instead of impressions. In order to place a bid from an ad with a PPO campaign into an exchange that requires bids in CPM, DV360 can use a conversion algorithm to determine an equivalent bid in CPM. [redacted]

[269] Google internal document, "Demand product for dummies," (February 2018) GOOG-AT-MDL-003109989 at '002 (HCI).
[270] Google internal document, "Demand product for dummies," (February 2018) GOOG-AT-MDL-003109989 at '993 (HCI).
[271] Google internal document, "Demand product for dummies," (February 2018) GOOG-AT-MDL-003109989 at '002 (HCI).
[272] [redacted] Deposition, (April 23, 2024) at 58:25-59:14; Google internal workbook, GOOG-AT-MDL-018630622 (HCI).
[273] 3 [redacted] Deposition, (April 23, 2024) at 59:17-61:3.
[274] Google Marketing Platform, "Improve Campaign performance with new automated bidding solutions," (September 2019) https://blog.google/products/marketingplatform/360/improve-campaign-performance-new-automated-bidding-solutions/. Accessed May 23, 2024.

[redacted] Figure 10 demonstrates the ad serving process after DV360 PPO was introduced.[276]

96. According to Google's public documentation, outcome-based buying for DV360 was discontinued in July 2023.[278]

J. Google's ad serving functionality changed over time

97. Google's ad serving functionality has gone through many changes over time as Google acquired new products and introduced new auction rules, mechanics and technologies that affected the ad serving process. These changes include the introduction of Enhanced Dynamic Allocation, Header Bidding, Exchange Bidding, and Unified Pricing Rules, among others, all of which significantly modified the process through which impressions are bought and sold. The changes introduced by these programs and technologies are described in detail in Sections VII, VIII, IX, and XIV. respectively. Here, I provide a high-level overview of the ways in which these programs and technologies changed the ad serving process. Figure 11 depicts a timeline of the implementation of the auction serving changes. Figure 12 shows an overview of the ad serving process and the order in which auction steps occur.

[275] Google internal document, "CAT2 1P," (September 29, 2021) GOOG-AT-MDL-001132667 at '672 (CI).
[276] Google internal document, "CAT2 1P," (September 29, 2021) GOOG-AT-MDL-001132667 at '672 (CI). Some documents refer to CAT2 as the Google Ads auction, excluding DV360, while other documents show DV360 bidding through CAT2 after the transition of DV360 to the Google Ads stack in 2014-2017.
[277] Google internal document, "CAT2 1P," (September 29, 2021) GOOG-AT-MDL-001132667 at '672 (CI). This diagram simplifies the serving process to demonstrate the general way in which DV360 PPO competes with Google Ads.
[278] Display & Video 360 Help, "What's new: July 2023," (July 2023) https://support.google.com/displayvideo/answer/13840246. Accessed May 23, 2024.

98. The "waterfall auction" was the earliest way publishers sold inventory that had not already been sold via direct deals.[279] The waterfall auction involves passing an ad request from demand source to demand source (ad exchange or network) until it is filled.[280] Prior to the introduction of Dynamic Allocation and later the emergence of Header Bidding and Exchange Bidding, waterfalls were the only method publishers could use to fill inventory that was not sold through direct deals.[281] To set up a waterfall, publishers generated line items within DFP with CPMs that were based on the historical performance of each exchange.[282]

99. As an example of a waterfall configuration, if Exchange A historically returns $2.00 bids, and Exchange B historically returns $1.00 bids, a publisher may choose to pass their impression first to Exchange A, and if it is unable to fill the impression, it would pass the impression to Exchange B. An impression would be passed from exchange to exchange until one of the exchanges could fill the impression at or above the floor price, at which point the advertisement would be served to the user.

100. With the introduction of Header Bidding and Exchange Bidding, third-party ad networks and exchanges gained the opportunity to compete for DFP publisher's inventory in real-time, alongside AdX.[283] Instead of using historical performance to determine an order for demand sources, all demand sources submit bids simultaneously.[284] However, a complex system of prioritization still determines the outcome of the auction.

101. Figure 11 below shows a high-level timeline of major changes to Google's ad serving functionality. In the next section, I provide a step-by-step overview of the current ad serving process.

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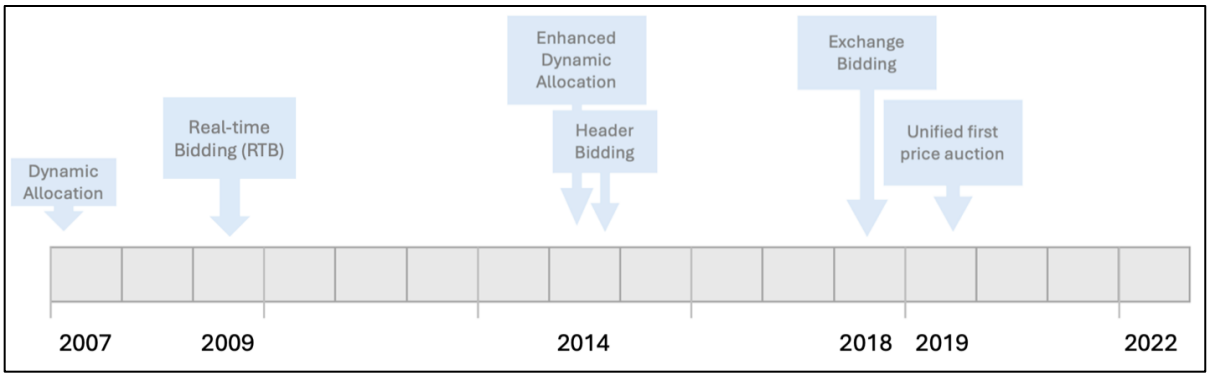
[279] Google document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '878-879 (HCI).
[280] Google document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '878-879 (HCI).
[281] Google document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '878-879 (HCI).
[282] Google document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '878-879 (HCI).
[283] Zaiceva A., setupad, "Header Bidding vs. Waterfall | Difference Explained," (July 17, 2021) https://setupad.com/blog/header-bidding-vs-waterfall/. Accessed May 23, 2024; Google Ad Manager Help, "Introduction to Open Bidding," https://support.google.com/admanager/answer/7128453. Accessed May 23, 2024.
[284] Zaiceva A., setupad, "Header Bidding vs. Waterfall | Difference Explained," (July 17, 2021) https://setupad.com/blog/header-bidding-vs-waterfall/. Accessed May 23, 2024.

Figure 11: Timeline of major changes to ad serving functionality[285,286]



K. Overview of Google's display ad serving process

102. When a user opens a website with advertisements, such as an online newspaper, an ad request is sent to the publisher's ad server that procures bids from a variety of sources, selecting one to be rendered on the page.[287] Google, which owns both an ad server and ad exchange, has a complex serving stack that enables this process, and this stack has undergone many changes over the years as Google integrated acquired products and developed their technology.

103. The following outlines the steps that occur once the user's browser loads the publisher's webpage:[288]

1) An impression becomes available on the publisher's webpage.

2) If the publisher participates in Header Bidding, the Header Bidding code on the webpage pauses the GPT tag from calling DFP and sends bid requests to the publisher's Header Bidding partners first.[289]

i. Header Bidding, introduced around 2014 and widely adopted around 2015, allowed publishers to send ad requests to multiple exchanges and networks to compete in a singular auction, outside of GAM, prior to sending an ad request to DFP.[290] To implement Header Bidding, publishers must include an HTML tag with

[285] Placement of events is approximate.
[286] Additionally, in 2012 the OpenRTB Standard was adopted by Interactive Advertising Bureau (IAB), the advertising organization providing industry standards, research and professional development, and promoting the growth of interactive advertising for its hundreds of member companies.
[287] Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '767 (HCI).
[288] Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '767 (HCI).
[289] Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '767 (HCI).
[290] Zaiceva A., Setupad, "What is Header Bidding? | A Complete Guide for Publishers," (April 4, 2022) https://setupad.com/blog/what-is-header-bidding/. Accessed May 23, 2024.

JavaScript code called a "Header Bidding tag" on their page that is used to communicate with one or more Header Bidding partners.[291] Header Bidding is described in detail in Section VIII.

3) The Header Bidding bids are returned to the browser.

4) The GPT tag sends an ad request to DFP, which includes the Header Bidding response.[292]

5) DFP invokes Enhanced Dynamic Allocation, which estimates a CPM value for both guaranteed and remnant line items.[293]

i. Enhanced Dynamic Allocation ("EDA") was introduced on March 3, 2014 and allows AdX and remnant line items to compete with guaranteed line items in real-time. [294] An in-depth description of Dynamic Allocation and Enhanced Dynamic Allocation are provided in Sections VI and VII.

104. DFP constructs a bid request that contains price floor information. Price floor information is determined by a variety of factors including the CPM values calculated by EDA, publisher-set pricing rules and floors determined by Google's "optimization" models (such as RPO). Price floors and RPO are discussed in detail in Sections XIII and XIV.

1) The bid request is sent to AdX, which in turn collects bids from Google (Google Ads and DV360) buyers, Authorized Buyers, and Exchange Bidding buyers.

i. Authorized Buyers are ad networks and other platforms that are allowed to buy on behalf of multiple advertisers in AdX using real-time bidding.[295] As they represent multiple advertisers, Authorized Buyers do not use Google's buying tools such as Google Ads and DV360.

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[291] Zaiceva A., Setupad, "What is Header Bidding? | A Complete Guide for Publishers," (April 4, 2022) https://setupad.com/blog/what-is-header-bidding/. Accessed May 23, 2024.
[292] Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '767 (HCI); see Section IV.A on line items. Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '767 (HCI)
[293] Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '741 (HCI).
294 Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 11.
[295] Google, "Authorized Buyers overview," https://support.google.com/authorizedbuyers/answer/6138000?hl=en. Accessed May 30, 2024.

ii. Exchange Bidding ("EB"), also known as Open Bidding ("OB"), was launched in February 2018 and was Google's server-side alternative to Header Bidding.[296] It allows third-party exchanges to compete for ad slots alongside AdX in real-time. Exchange Bidding is described in detail in Section IX.

2) DFP runs a single unified auction, in which AdX demand, Exchange Bidding demand, remnant and guaranteed line items all compete against one another on a first-price basis.[297] The highest bid wins the auction.

i. The unified first-price auction and Unified Pricing Rules (UPR) were introduced in May 2019.[298] Under UPR, the publisher-set floor applies to all indirect demand, which includes Exchange Bidding participants, remnant line items (including Header Bidding, where third-party buyers can submit bids in real-time), and the AdX auction.[299] Therefore, all demand sources compete in a final first-price auction with a single floor.[300] I describe the unified auction and Unified Pricing Rules in greater detail in Section XIV.

3) The ad from the winning demand or line item is served. DFP constructs a response to the original ad request, which contains the ad to be served or a link for the browser to download the ad.[301]

i. To select the ad to serve, DFP filters the ads corresponding to the winning demand, accounting for the size of the ad, the format of the ad, and whether the ad has already been shown elsewhere on the page.[302] If the winning demand has at

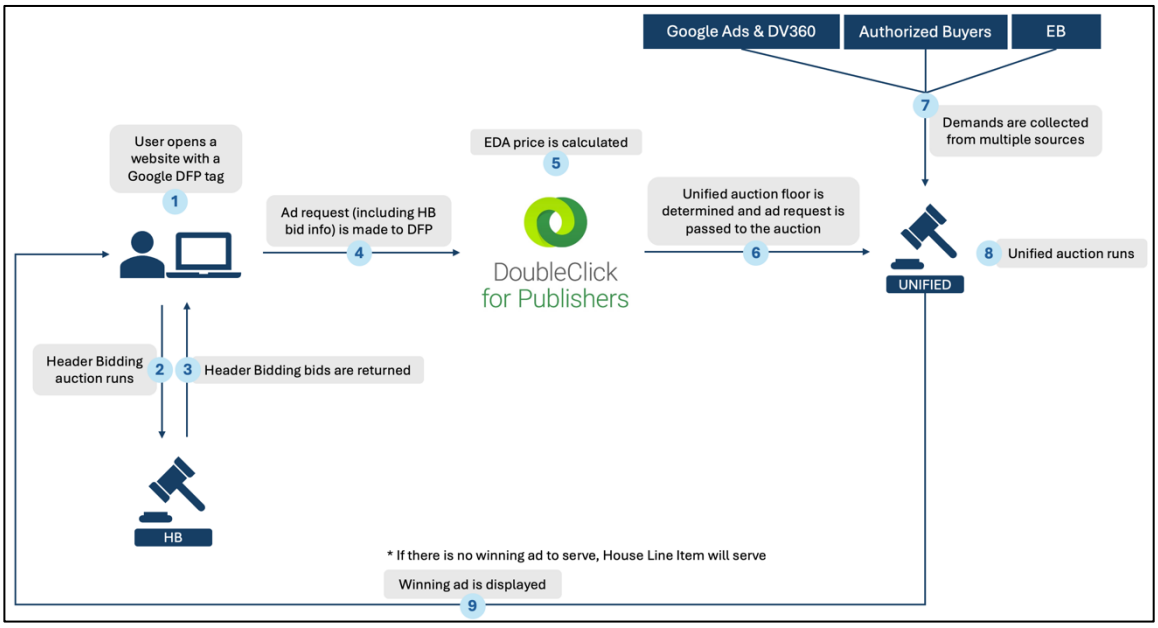
[296] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 11. Note that the open beta for Exchange Bidding, which was available to all publishers using DFP, was released in June 2017; Cox, S., "Announcing Exchange Bidding open beta," (June 8, 2017) https://blog.google/products/admanager/announcing-exchange-bidding-open-beta/. Accessed May 23, 2024.
[297] Google internal document, "Skyray Overview," GOOG-TEX-00217546 at '551 (HCI).
[298] Google internal document, "Unified 1st Price Auction," (September 3, 2019) GOOG-DOJ-AT-01812188 at '195 (HCI).
[299] Google Ad Manager Help, "Unified pricing rules," https://support.google.com/admanager/answer/9298008. Accessed May 23, 2024.
[300] Google internal document, "1st Price Migration," GOOG-DOJ-28243636 at '645 (CI).
[301] Google, "Ad selection white paper," https://support.google.com/admanager/answer/1143651?sjid=16185194441614631351-NA. Accessed June 6, 2024.
[302] Google, "Ad selection white paper," https://support.google.com/admanager/answer/1143651?sjid=16185194441614631351-NA. Accessed June 6, 2024.

least one ad available after filtering, the ad will serve.[303] Otherwise, DFP moves to the next best demand or line item from the auction and repeats the filtering process until an ad is available.[304]

ii. Occasionally, no AdX demand, Exchange Bidding demand, guaranteed line item, or remnant line item wins the auction. In these cases, a House line item, which usually contains an ad for the publisher's own website or products, serves the impression.[305]

105. Figure 12 below gives a high-level overview of this process.

Figure 12: Overview of Google display ad serving process[306]



V. GOOGLE UNIFIED ITS AD SERVER AND AD EXCHANGE INTO A SINGLE PRODUCT

[303] Google, "Ad selection white paper," https://support.google.com/admanager/answer/1143651?sjid=16185194441614631351-NA. Accessed June 6, 2024.
[304] Google, "Ad selection white paper," https://support.google.com/admanager/answer/1143651?sjid=16185194441614631351-NA. Accessed June 6, 2024.
[305] Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '719 (HCI); Google, "House line items," https://support.google.com/admanager/answer/79305?hl=en. Accessed May 23, 2024.
[306] Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '767 (HCI).

106. In the early days of Google's ad stack, AdX was designed to interoperate with third-party ad servers and ad networks. Over time, Google consolidated its products, culminating in the unification of DFP and AdX into GAM.[307] However, as Google proceeded with unification, AdX's capability to interoperate with third party platforms stagnated over time.

A. AdX was initially built on top of Google's existing ad stack as an intermediary between publishers and advertisers

107. By the time Google acquired DoubleClick in 2007, Google had already developed several advertising technologies of its own.[308] Among those technologies were AdSense, released in 2003, and AdWords, released in 2000;[309] these technologies are described earlier in Section III. Originally, AdSense and AdWords solely interacted with each other as the seller and buyer, respectively.[310]

108. In 2009, Google rebuilt the AdX technology it acquired from DoubleClick and released it as a new version of AdX.[311] This version of AdX included several new features, including a new user interface (UI), application programming interface (API), ad server, reporting system, and real-time bidding engine.[312] As an exchange, AdX introduced the possibility for indirect deals: in addition to direct deals, publishers and advertisers could now participate in auctions for inventory.[313] Advertisers, including those using AdWords, would submit bids to AdX for inventory from various publishers, including those using AdSense.[314] In other words, AdSense sellers could access AdX bids, while AdWords buyers could access AdX inventory.[315]

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[307] [redacted] Deposition, (April 12, 2024) at 137:14-138:18.
[308] Google, "Google to Acquire DoubleClick," (April 13, 2007) https://googlepress.blogspot.com/2007/04/google-to-acquire-doubleclick_13.html. Accessed May 23, 2024.
[309] Google, "Google Expands Advertising Monetization Program for Websites," (June 18, 2003) https://googlepress.blogspot.com/2003/06/google-expands-advertising-monetization.html. Accessed May 23, 2024; Google, "Google Launches Self-Service Advertising Program," (October 23, 2000) https://googlepress.blogspot.com/2000/10/google-launches-self-service.html. Accessed May 23, 2024.
[310] Google internal document, "Ad Exchange Update," (May 5, 2009) GOOG-NE-06567200 at '202 (HCI); Google internal document, "Responses to Questions 1, 4-25, 28-36, and 39-52 of the Autorite de la Concurrence's Request for Information dated 23 July 2019 Case No. 19/0030F," (July 23, 2019) GOOG-DOJ-05782415 at '421 (CI).
[311] Google internal document, "Ad Exchange 2.0 Design Document," GOOG-NE-05241093 at '093 (HCI).
[312] Google internal document, "Ad Exchange 2.0," GOOG-NE-11839088 at '089 (HCI).
[313] "The Advertising Exchange - providing a common trading platform and set of controls for the indirect sales channel allows sellers to expose inventory to the largest possible universe of buyers on their own terms." Google internal document, "Ad Exchange Update," (May 5, 2009) GOOG-NE-06567200 at '201 (HCI).
[314] Google internal document, "Ad Exchange Update," (May 5, 2009) GOOG-NE-06567200 at '202 (HCI).
[315] Google internal document, "Ad Exchange Update," (May 5, 2009) GOOG-NE-06567200 at '202 (HCI).

109. AdX was built on top of Google's existing ad stack to connect publishers and advertisers, and had similarities with Google's existing products, AdSense and AdWords.[316] For example, AdX's sell-side UI was similar to AdSense's UI, and AdX's buy-side UI was similar to AdWords' UI.[317] Using these UIs, sellers could list inventory as ad units and allocate inventory for auction via AdSense or AdX, while buyers could bid on inventory allocated via AdWords or AdX.[318]

110. Although AdX was connected to the rest of Google's ecosystem, a publisher did not have to use AdSense and an advertiser did not have to use AdWords to use AdX. For example, on the buy-side AdX accepted bids from a variety of ad networks and buying tools, all bids were equalized to the ad slot's minimum CPM minus the buyer cost to determine whether they would be accepted into the auction, and all accepted bids ran in the same auction.[319] Third-party demand side platforms would interact with AdX through a real-time bidding (RTB) API, where AdX would pass the buyer information such as the user's IP address and cookie, and the buyer would pass AdX information such as the bid and ad to be served, should the buyer win the auction.[320]

111. [redacted]

112. AdX could also integrate with DFP, though the two platforms remained separate at the time. AdX integrated with DFP in the sense that AdX ads could compete with directly sold DFP ads at a specified priority level, and the ad with the highest yield would be served through Dynamic

[316] Google internal document, "Ad Exchange Update," (May 5, 2009) GOOG-NE-06567200 at '203 (HCI).
[317] "The initial development of the exchange will focus on only the spot market and a sub-set of the buy-side and sell-side tools, accessed via a user interface similar to AdWords (AW) / AdSense (AS) front-ends." Google internal document, "Ad Exchange 2.0 Design Document," GOOG-NE-05241093 at '094 (HCI); Google internal document, "Ad Exchange Update," (May 5, 2009) GOOG-NE-06567200 at '203 (HCI).
[318] Google internal document, "Ad Exchange 2.0 Design Document," GOOG-NE-05241093 at '096 (HCI).
[319] Google internal document, "Ad Exchange Update," (May 5, 2009) GOOG-NE-06567200 at '207-208 (HCI).
[320] Google internal document, "Ad Exchange 2.0," GOOG-NE-11839088 at '099-101 (HCI).
[321] [redacted] Deposition, (May 23, 2024) at 142:4-14; 147:1-9.

Allocation, a feature exclusive to DFP discussed in detail in Section VI.[322] A transaction for an impression would trigger when a user visited a webpage with a tag from DFP.[323] AdX would then be checked for matching buyers for bids that were above the minimum CPM of the ad slot and that satisfied all targeting criteria set by the publisher.[324] For each matching buyer, if the bid net of revenue share was higher than the value of the ad booked directly in DFP, the AdX buyer would win the auction.

113. It was also possible for publishers to use AdX without using DFP, and AdX was originally designed such that it could be used regardless of whether a publisher used DFP and or a third-party ad server.[325] If the publisher was using a non-DFP ad server as its primary ad server, the ad server could communicate with AdX using an AdX callout integration that interacted with an AdX API.[326] When the publisher's ad server called the API, the ad server would send data including the minimum CPM, restrictions, and information on the impression.[327] In response to the API call from the ad server, AdX would return the two highest bids for the impression and a "pointer" to the ad associated with the highest bid.

114. Thus, AdX was designed to integrate with Google's existing ad stack, including AdSense, AdWords, and DFP. However, at the time of AdX's launch publishers and advertisers did not have to use Google's existing ad stack to use AdX, and could use their own buying tools, ad networks, and/or ad servers.

B. Google unified DFP and AdX into GAM

115. As early as 2014, Google made the decision to unify DFP and AdX into a single platform.[328] Google's efforts resulted in the release of GAM in 2018. Some GAM features included:[329]

[322] Google internal document, "Seller Migration Training," GOOG-AT-MDL-015236044 at '078 (CI).
[323] Google internal document, "Ad Exchange 2.0 Design Document," GOOG-NE-05241093 at '096-097 (HCI).
[324] Google internal document, "Ad Exchange 2.0 Design Document," GOOG-NE-05241093 at '096-097 (HCI).
[325] Google document, "Ad Exchange 2.0 Design Document," GOOG-NE-05241093 at '096-097 (HCI).
[326] Google document, "The Display Advertising Opportunity," GOOG-NE-02110867 at '877 (HCI).
[327] Google document, "Ad Exchange 2.0 Design Document," GOOG-NE-05241093 at '096-097 (HCI).
[328] Google document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '934 (HCI); [redacted] Deposition, (April 12, 2024) at 146:24-147:12.
[329] Bellack, J., "Introducing Google Ad Manager," (June 27, 2018) https://blog.google/products/admanager/introducing-google-ad-manager/. Accessed May 23, 2024.

1) Programmatic solutions such as "[Google's] programmatic deals framework to features like Optimized Competition that help [publishers] maximize yield across reservations, private marketplaces, and the open auction."[330]

2) Features to "curate who has access to [publishers'] inventory, alongside all [publishers'] reservation and programmatic demand, and optimize [publishers'] relationships for yield."

3) A platform for publishers to deliver, measure, and optimize ads for their audiences.

4) Features to manage ads' alignment with publishers' brand values and protect user safety.

116. Additionally, Google built a single UI from which users could access both DFP and AdX.[331] Google stated that this UI would allow for a "seamless transition" between DFP and AdX to save publishers time from tasks such as fixing errors or manual data entry.[332]

117. Google also integrated DFP and AdX's ad serving infrastructure over time. [redacted]

[330] "Optimized Competition is a suite of features in GAM that include systems such as Dynamic Allocation and First Look." Google, "Optimized competition," https://support.google.com/admanager/answer/7422526. Accessed May 23, 2024.
[331] Google internal document, "DFP and AdX Integration," GOOG-TEX-00045314 at '333 (HCI).
[332] Google internal document, "DFP and AdX Integration," GOOG-TEX-00045314 at '333 (HCI).
[333] Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '597 (HCI).
[334] Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '597 (HCI); Google internal document, "go/demand-product-design-doc," (January 15, 2018) GOOG-DOJ-14609574 at '578 (HCI). Note that CAT2 BOW and CAT2 Supermixer were also known as AFC (AdSense for Content) BOW and Supermixer respectively.
[335] "At a high level [,] the goal for AURAS is to change the way DFP retrieves ads from our auction products. Historically, it has made an HTTPOverRPC call to CAT2 BOW … and received a fully rendered ad that it must serve[.]" Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '597 (HCI).
[336] Google internal document, "Auras," (April 9, 2021) GOOG-AT-MDL-B-005180709 at '709 (HCI).

1) [redacted]

118. Thus, Google unified DFP and AdX by integrating their ad serving stacks into one, and then building additional features on top of the unified stack. This culminated in the release of GAM.

C. Google reinforced the DFP-AdX unification using GPT tags

119. While Google was unifying DFP and AdX's ad serving stacks, Google changed its implementation of ad tags such that they would be used to direct traffic to GAM. As discussed in Section IV.B, ad tags are pieces of code placed on a publisher's website to communicate with an ad server and send ad requests. Google offered several types of tags, including the GPT tag and the AdX tag. To reiterate, GPT tags were introduced to replace DFP tags and function by sending a request to DFP, which then sends a backfill call to AdX. On the other hand, AdX tags do not send ad requests to DFP, but instead enable publishers to use AdX with a third-party ad server instead of DFP: this method of using AdX as a standalone product is also known as "AdX Direct."[342]

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[337] Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '600 (HCI); Google internal document, "Display Ad Serving: Sellside POV," (July 2022) GOOG-AT-MDL-012693796 at '829 (HCI).
[338] Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '600 (HCI).
[339] Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '600 (HCI); Google internal document, "Display Ad Serving: Sellside POV," (July 2022) GOOG-AT-MDL-012693796 at '829 (HCI).
[340] Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '600, '603 (HCI).
[341] Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," (2018) GOOG-DOJ-13615596 at '606-607 (HCI); Google internal document, "Display Ad Serving: Sellside POV," (July 2022) GOOG-AT-MDL-012693796 at '829 (HCI).
[342] Google internal document, "AdX Direct Review," (February 11, 2020) GOOG-DOJ-27799214 at '215 (CI); [redacted] Deposition, (April 12, 2024) at 323:3-330:16; 331:11-14.

120. AdX tags are therefore embedded in websites of publishers that use non-Google ad servers.

[redacted]

121. Although AdX tags allow publishers to use ad servers other than DFP, they have several functional limitations compared to GPT tags. [redacted]

343 Google internal document, "go/demand-product-design-doc," (January 15, 2018) GOOG-DOJ-14609574 at '577 (HCI); Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '597 (HCI). [redacted]

344 Google internal document, "go/demand-product-design-doc," (January 15, 2018) GOOG-DOJ-14609574 at '577 (HCI); Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '597 (HCI).

345 Google internal document, "go/demand-product-design-doc," (January 15, 2018) GOOG-DOJ-14609574 at '577 (HCI); Google internal document, "Project AURAS: A Unified Reservation/Auction Stack," GOOG-DOJ-13615596 at '597 (HCI). Note that CAT2 BOW was also known as AFC BOW, and CAT2 Supermixer was also known as Supermixer.

[redacted] Similarly, ad requests sent by AdX tags are ineligible for DFP deals such as Programmatic Guaranteed and Preferred Deals, which further restricts the types of demand available to AdX tag users.[347] As another example, Exchange Bidding (Open Bidding), Google's server-side solution to allow third-party exchanges to bid alongside AdX, was not available through AdX tags.[348] This meant that publishers using AdX tags could not access third-party exchanges through AdX. Thus, though AdX tags allowed AdX to be interoperable with third-party ad servers, publishers using AdX tags did not have access to all the features included with GPT tags.

122. By the time Google made the decision to unify DFP and AdX in 2014, Google proposed that "all publishers should be using effectively a single tag."[349] This single tag was the GPT tag. Google explored several solutions to direct traffic through the GPT tag, including:

1) [redacted]

[346] Google internal document, "Responses to Questions 1, 4-25, 28-36, and 39-52 of the Autorite de la Concurrence's Request for Information dated 23 July 2019 Case No. 19/0030F," (July 23, 2019) GOOG-DOJ-05782415 at '439 (CI).
[347] "If you have an AdX tag on a page, and DFP ad units that were created because they are mapped to the adx ad slot that matches that tag and then target the ad unit in PD or PG, it won't break, but the deal would never get called b/c the tag is not eligible for those types of deals[.]" Google internal document, "Ad Unit Stuff (go/ad-unit-stuff)," GOOG-AT-MDL-004288612 at '643 (CI).
[348] Google internal document, "AdX Direct Review," (February 11, 2020) GOOG-DOJ-27799214 at '217 (CI).
[349] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '934 (HCI).
[350] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '957 (HCI).
[351] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '958 (HCI).
[352] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '977-978 (HCI).

2) [redacted]

123. These solutions made up Google's "GPT-for-AdX" project. To prioritize this strategy, Google proposed "postponing some feature and revenue projects to allow an immediate focus on GPT-for-AdX."[356] Google also proposed building tools to facilitate the migration from AdX tags to GPT tags, where an AdX tag on a publisher's webpage would be converted to a GPT tag.[357] Google considered building such a tool using third-party ad servers' APIs or making the tool open source for third parties to build on.[358]

124. Google's efforts to have publishers use GPT tags was a key component of its "own the tag" strategy, which meant "placing the Google Publisher Tag (GPT) on the page directly so Google owns the decision logic via DFP across all demand sources."[359] Google's transition to GPT tags and "own the tag" strategy also reinforced DFP's unification with AdX into GAM. By routing traffic to DFP, Google would determine "whether to serve a directly sold ad (programmatic or tag based) or an indirect ad[.]"[360] Then, by unifying DFP with AdX, ad requests routed to DFP would also be passed to AdX.

[353] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '967 (HCI).
[354] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '977-978 (HCI).
[355] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '977-978 (HCI).
[356] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '973 (HCI).
[357] Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '964 (HCI).
[358] "Have you dug into what ad server the pubs with the largest % of AdX tags use? It might be more useful to build a tool that does this using their APIs. Or open source the tool you're suggesting to let third parties build on it[.]" Google internal document, "Vision for Tagging Infrastructure," (June 16, 2014) GOOG-TEX-00260934 at '964 (HCI).
[359] Google internal document, GOOG-DOJ-28420330 at '338 (CI).
[360] Google internal document, GOOG-DOJ-28420330 at '338 (CI).

D. AdX interoperability with third parties stagnated over time

125. As discussed in Section V.A, AdX was initially designed to be interoperable with third parties, including those that did not use DFP, AdSense, or AdWords. However, as Google developed its "own the tag strategy" and unified DFP and AdX, third party interoperability stagnated over time.

126. As discussed above in Section V.A, when AdX initially launched publishers could access AdX with a third-party ad server using an AdX API. For years after AdX's launch, Google recognized that this sell-side API was an "increasingly critical part of the business for our publishers and the 3rd parties who help us create a robust ecosystem."[361] However, Google also stated that it was unclear how long the API would continue to be supported and that it was possible for the API to be internally deprecated.[362] One reason for the lack of continued support for the API and its eventual deprecation was the unification of DFP and AdX into GAM.[363] For example, a feature allowing AdX partners to efficiently manage domains was not planned to be implemented in the AdX API "in light of the DFP+AdX unification project."[364] Thus, Google focused on unification and routing traffic through its ad stack from top to bottom.

127. AdX tags and AdX Direct also experienced a similar lack of support over time. As discussed in Section V.C, publishers using AdX tags did not have access to all the features available through DFP and GAM, including DA / EDA and Exchange Bidding. As discussed in Sections VI, VII, and IX, these features allowed publishers to compete in real-time and enabled publishers to solicit bids from third-party exchanges in addition to AdX buyers, respectively. Thus, although AdX tags allowed publishers to use AdX without using DFP, they had limited functionality compared to using AdX and DFP together in GAM. Currently, AdX tags are still in use, and it is still possible for publishers to use AdX with a third-party ad server.[365] However, the lack of key features for AdX tags compared to GPT tags means that publishers making direct requests to AdX ultimately have fewer opportunities to maximize their yield and revenue.

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[361] Google internal document, "DRK PM Personal One-Pagers 2016," (June 2016) GOOG-DOJ-28486025 at '049 (CI).
[362] Google internal document, "DRK PM Personal One-Pagers 2016," (June 2016) GOOG-DOJ-28486025 at '049 (CI).
[363] "Unification brings DFP and AdX into a single UI and ultimately will deprecate the AdX API." Google internal document, "Per account ICS access," GOOG-NE-13216501 (HCI).
[364] Google internal document, GOOG-AT-MDL-007365338 at '366 (HCI).
[365] Google, "Generate Ad Exchange ad tags," https://support.google.com/admanager/answer/7501422. Accessed May 30, 2024.

VI. DYNAMIC ALLOCATION ALLOWS ADX TO COMPETE WITH REMNANT LINE ITEMS IN REAL-TIME

128. Dynamic Allocation (DA) is a mechanism within Google's DFP ad server that enables AdX and remnant line items to compete in real-time for ad impressions that were not fulfilled by guaranteed line items.[366]

A. Ad serving logic is traditionally governed by the ad waterfall process

129. Ad waterfalls, also known as daisy chains, are a process used by publishers to sell all their remnant inventory when they are unable to sell their premium ad slots, which are usually reserved for direct ad sales. The process was introduced to reduce the number of unfilled ad spaces and thus increase revenue opportunities for publishers. In a waterfall process, as its name suggests, demand sources (*e.g.*, ad networks and ad exchanges) are initiated one after another in a waterfall-like pattern to solicit bids for an impression.[367] To that end, if a publisher is unable to sell inventory via direct sales, they will then pass the ad impression down the waterfall to the next demand source. This process will continue until one of two situations are met. If a demand source can provide a suitable ad for the impression, then its ad is displayed on the dedicated ad space. Otherwise, if no demand sources can provide an impression, then the publisher displays an ad promoting its own products or services, which are referred to as "fallback" or "House" ads.[368]

130. Although waterfall auctions helped establish early ad serving logic, they have several technical limitations. One key disadvantage is that waterfall auctions are prone to latency, error, and timeout issues. This is because each stage of the waterfall takes time to load, so each stage increases the time it takes for an impression to be served. Another disadvantage is that the CPMs for each demand source and the order in which demand sources are called are typically set by the publisher based on average historical performance (for example, the average revenue generated per impression sold from a particular demand source) or a pre-negotiated price with a demand source.[369] Consequently, it is possible for a lower-ranking demand source willing to pay more for an impression to lose to a higher-ranking source that pays less.

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[366] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '881 (HCI); [redacted] Deposition, (May 23, 2024) at 105:11-108:16; [redacted] Deposition, (April 26, 2024) at 101:3-9.
[367] Google internal document, "Mediation and Exchange Bidding in DRX," (October 18, 2017) GOOG-AT-MDL-001110980 at '981 and '982 (CI).
[368] Google Ad Manager Help, "House line items," https://support.google.com/admanager/answer/79305?hl=en. Accessed June 6, 2024.
[369] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '878-879 (HCI).

B. Dynamic Allocation enables AdX to compete with remnant inventory in real-time

131. Dynamic Allocation (DA) was first launched by DoubleClick on July 11, 2007 as a purported solution to various inefficiencies in the traditional ad waterfall process.[370] Google states that DA solved these inefficiencies by allowing AdX and remnant line items (inclusive of third-party exchanges and networks, as detailed in Section VI.A) to compete against each other in real-time for an impression unfulfilled by a guaranteed line item.[371]

132. Google states that when DA was initially launched by DoubleClick, there was no "standard protocol that allowed non-AdX ad exchanges to integrate with DFP."[372] Thus, at the time AdX was the only exchange with the "technical capability to submit real-time bids into DFP."[373] Since DA was a core part of DFP and AdX since its initial launch, the only way for publishers to not use DA was to not call AdX.[374]

133. DA proceeded in the following steps:

1) DFP determined if there was a guaranteed line item eligible to fulfill an ad impression. As discussed in Section IV.A, guaranteed line items are contractually obligated to deliver a specified number of impressions. If such a guaranteed line item existed, DA would not run.[375]

2) Otherwise, a floor price was calculated based on the highest net value CPM (vCPM) of the publisher's remnant line items.[376] The vCPM was first specified by publishers, either

[370] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '880 (HCI); [redacted] Deposition, (May 23, 2024) at 105:11-108:16; Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 11.
[371] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '881 (HCI).
[372] Google internal document, "Digital Advertising Market Study: Follow-up to Google/CMA meeting on 28 October 2019," GOOG-AT-MDL-006690096 at '096 (CI); Standard protocols for real-time bidding were developed several years after the launch of DA. The OpenRTB protocol is an example of such a protocol; IAB Tech Lab, "OpenRTB," https://iabtechlab.com/standards/openrtb/. Accessed May 23, 2024; Google, "OpenRTB Integration," https://developers.google.com/authorized-buyers/rtb/openrtb-guide. Accessed May 23, 2024.
[373] Google internal document, "Digital Advertising Market Study: Follow-up to Google/CMA meeting on 28 October 2019," GOOG-AT-MDL-006690096 at '096 (CI).
[374] [redacted] Deposition, (May 2, 2024) at 395:5-398:22.
[375] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '881 (HCI).
[376] See Appendix C Section B.6 for findings based on my analysis of Google's source code on the calculation of vCPM in DA.

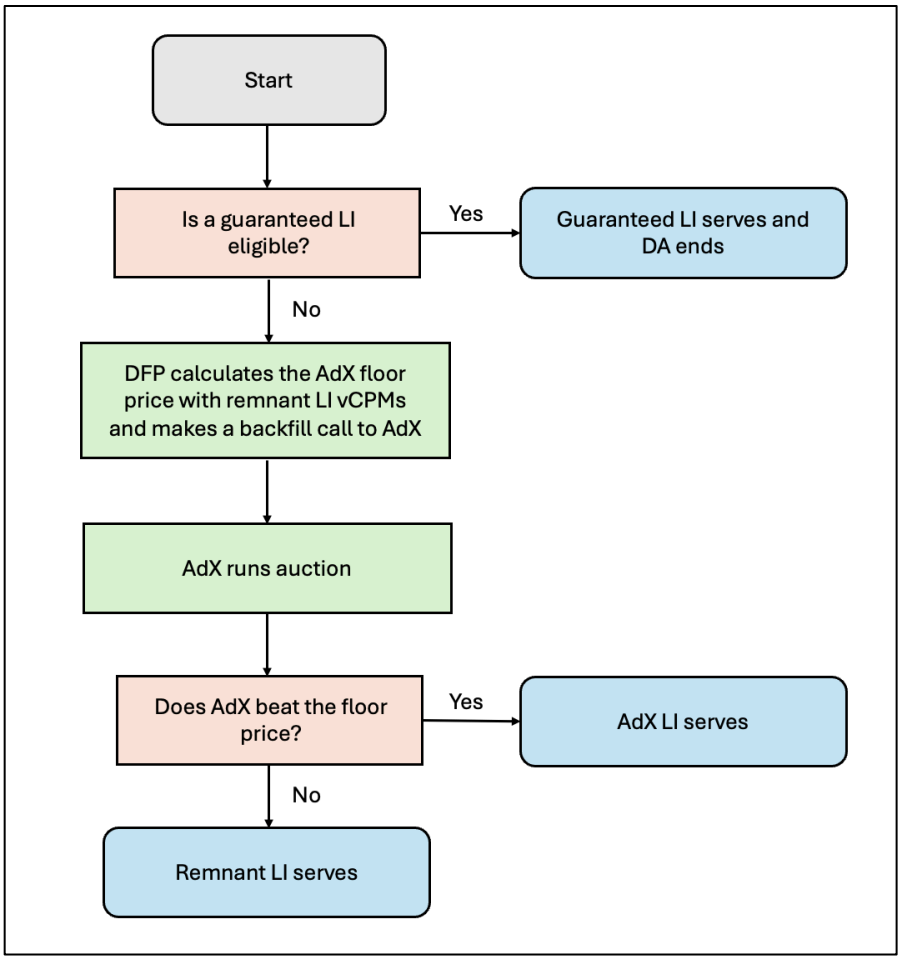
as the pre-negotiated CPM price with the line item's corresponding demand partner or as an estimate of the CPM the line item would likely generate based on historical performance.[377] [redacted]

3) AdX ran an auction to select the winning bidder. If the highest bid from AdX was above the floor price, even if only by a single penny, then AdX won the impression. Otherwise, the static remnant line item with the highest vCPM or a negotiated price won.[383] An ad corresponding to the winning AdX demand or the remnant line item would be served, as discussed in Section IV.K.

134. Figure 14 below illustrates the process of DA as a flowchart.

[377] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '881 (HCI); Google, "Value CPM," https://support.google.com/admanager/answer/177222. Accessed May 23, 2024; See Appendix C Section B.5 for findings from my analysis of Google's source code on vCPM specified by publishers.
[378] See Appendix C Section B.6 for findings from my analysis of Google's source code on the calculation of vCPM in DA; See Appendix C Section B.7 for findings from my analysis of Google's source code on the calculation of vCPM and DA floor price.
[379] Google, "Clickthrough rate (CTR): Definition," https://support.google.com/google-ads/answer/2615875. Accessed May 23, 2024; [redacted] Deposition, (April 3, 2024) at 145:6-148:22.
[380] "[Backfill is defined as:] Inventory that has not been pre-sold or reserved. As a verb, 'backfill' means to serve ads to this inventory. Backfill inventory is often monetized with ads sold by ad networks, via non-guaranteed campaigns, or in an auction." Google, "Glossary," https://support.google.com/admanager/table/7636513. Accessed May 23, 2024.
[381] See Appendix C Section B.2 for findings from my analysis of Google's source code on the data representation of the backfill call.
[382] Google sometimes refers to DA as "backfill" in internal documents. Google internal document, "Mysteries of Dynamic Allocation SOLVED," (December 15, 2011) GOOG-TEX-00074558 at '562 (HCI); See Appendix C Section B.1 for findings from my analysis of Google's source code, where I verified the backfill type and call flow. AdX buyers were only involved in line item backfill. Google internal document, "Mysteries of Dynamic Allocation SOLVED," (December 15, 2011) GOOG-TEX-00074558 at '562 (HCI).
[383] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '881 (HCI).

Figure 14: Dynamic Allocation flowchart[384]



135. Google viewed DA as limiting because DA would not be called if there was a guaranteed line item eligible to fulfill an impression. In other words, neither AdX nor remnant line items could compete with guaranteed line items.[385] For AdX to compete with guaranteed line items, Google created a more comprehensive version of DA known as Enhanced Dynamic Allocation (EDA), as discussed in Section VII.

[384] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '881 (HCI); Google internal document, "Mysteries of Dynamic Allocation SOLVED," (December 15, 2011) GOOG-TEX-00074558 at '562 (HCI).
[385] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '880-882 (HCI).

C. After acquiring AdMeld, Google developed Third-Party Dynamic Allocation to allow AdMeld publishers to access real-time AdX demand but it was ultimately not launched

136. In June 2011, Google acquired a platform called AdMeld.[386] Google described AdMeld as a "yield manager" that helped publishers manage inventory sales.[387] In particular, AdMeld supported real-time bidding since 2009 and was capable of handling bids from multiple demand sources (including DSPs and ad networks) to compete in a single real-time auction.[388]

137. After acquiring AdMeld, Google began developing a project called "AdX Connect" or "Third-Party Dynamic Allocation" (3PDA) as an interim integration of AdMeld into Google's ad serving stack.[389] 3PDA would have allowed AdX buyers to compete with demand sources buying through AdMeld in an AdMeld-hosted auction for AdMeld publisher inventory.[390] However, 3PDA was not released to the general public: it was announced in March 2012, remained in limited beta in April 2012, and was deprecated in October 2013 when Google shut down AdMeld entirely.[391,392]

VII. ENHANCED DYNAMIC ALLOCATION ENABLES ADX AND REMNANT LINE ITEMS TO COMPETE WITH GUARANTEED LINE ITEMS IN REAL-TIME

[386] Google, "Helping publishers get the most from display advertising with Admeld," (June 13, 2011) https://googleblog.blogspot.com/2011/06/helping-publishers-get-most-from.html. Accessed June 3, 2024.
[387] Google, "Helping publishers get the most from display advertising with Admeld," (June 13, 2011) https://googleblog.blogspot.com/2011/06/helping-publishers-get-most-from.html. Accessed June 3, 2024; AdMeld, "Superior Technology, Superior Results," https://web.archive.org/web/20101225163051/http://www.admeld.com/technology.html. Accessed May 31, 2024; Google internal document, "Programmatic - AdX - RTB - DSP," (March 20, 2013) GOOG-AT-MDL-012530559 at '569 (CI).
[388] AdMeld, "Superior Technology, Superior Results," https://web.archive.org/web/20101225163051/http://www.admeld.com/technology.html. Accessed May 31, 2024.
[389] Google internal document, "AdX Connect Comms Doc," (April 26, 2012) GOOG-AT-MDL-017084371 at '371-372 (CI).
[390] Google internal document, "AdX Connect Comms Doc," (April 26, 2012) GOOG-AT-MDL-017084371 at '371-372 (CI).
[391] Google internal document, "AdX Connect Comms Doc," (April 26, 2012) GOOG-AT-MDL-017084371 at '371-372 (CI).
[392] Google internal document, "Recap of Ads Deals 2005-2013," (February 2014) GOOG-AT-MDL-004122442 at '444 (CI).

138. Google introduced Enhanced Dynamic Allocation (EDA)[393] in March 2014.[394] EDA allowed both AdX and remnant line items to also compete against guaranteed line items while protecting guaranteed line items' campaign goals.[395]

139. Internal Google documents indicate that after the EDA launch, Google pushed publishers to switch from DA to EDA to "get all [publishers] on EDA and make it the default DA."[396] As a result, Google moved all its publishers to EDA by September 2016.[397] This section describes the EDA process in detail and how it allows AdX and remnant line items to compete with guaranteed line items in real-time.

140. The EDA process has changed over time, particularly in 2019 when Google switched to Unified Pricing Rules and first-price auctions as discussed in Section XIV. Before 2019, EDA occurred with the following steps:

141. DFP calculated a temporary CPM (tCPM) for each guaranteed line item and selected the guaranteed line item with the highest tCPM.[398] The tCPM values represented estimated opportunity costs for not serving a guaranteed line item in favor of an AdX or other remnant line

[393] In the past, Enhanced Dynamic Allocation was also referred to by Google internally as Cross-Priority Ranking as it enabled line items of different priorities to compete with one another. See Google internal document, "Enhanced Dynamic Allocation Overview (EDA)," (March 13, 2017) GOOG-TEX-00830552 at '552 (HCI); All mentions of the term "DA" or "Dynamic Allocation" in Google's internal documents and official webpages after 2014 refer to Enhanced Dynamic Allocation.
[394] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 11.
[395] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '489 (HCI).
[396] Google internal document, "[OLD] – Meeting Notes – DRX Indirect Commercialization," (December 18, 2017)
GOOG-TEX-00971457 at '586 (HCI).
[397] Google internal document, "GPSI Bi-Weekly Snippets," (June 9, 2017) GOOG-NE-09149436 at '537 (HCI).
[398] This value has also been called the "EDA price" in Google documents, which is "at least the PG [Programmatic Guaranteed] price, plus the opportunity cost determined by how far behind/ahead-schedule this PG deal is." Google internal document, "EDA for Programmatic Guaranteed Deals," GOOG-AT-MDL-009013305 at '308 (HCI).

item.[399] The more behind schedule a guaranteed line item was, the higher its tCPM value.[400]

2)

3)

[399] Google internal document, "AdX Buy-side Commercialization," GOOG-NE-04415172 at '316 (HCI).
[400] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '489 (HCI); "Dynamic allocation protects delivery of guaranteed line items by automatically adjusting the temporary CPM. Therefore, a guaranteed line item that is behind schedule wins often enough to stay on pace to satisfy its goal and pacing settings." Google, "Ad competition with dynamic allocation," https://support.google.com/admanager/answer/3721872. Accessed May 23, 2024; Deposition, (May 2, 2024) at 383:3-18.
[401] Google internal document, "DRX Ad Ranking and Auction Introduction," (October 2019) GOOG-DOJ-AT-00167982 at '994 (HCI); Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '489 (HCI).
[402] See Appendix C Section B.17 for findings from my analysis of Google's source code on the calculation of tCPM in EDA.
[403] See Appendix C Section B.8 for findings from my analysis of Google's source code on the calculation of acceptance probability.
[404] "If the temporary CPM is too high, Ad Manager doesn't call Ad Exchange, which explains why sometimes the number of 'Impressions competing' is lower than the 'Eligible impressions' in reports." Google, "Ad competition with dynamic allocation," https://support.google.com/admanager/answer/3721872. Accessed May 23, 2024.
[405] See Appendix C Section B.18 for findings from source code analysis on ad selection process and impact of acceptance probability in EDA.
[406] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '489 (HCI).
[407] See Appendix C Section B.9 for findings from my analysis of Google's source code on the calculation of vCPM in EDA.

4) [redacted]

1) [redacted]

2) [redacted]

ii. [redacted]

[408] Google document, "Display Ad Serving: Sellside POV," (July 2022) GOOG-AT-MDL-012693796 at '824 (HCI).
[409] Google internal document, "EDA for Programmatic Guaranteed Deals," GOOG-AT-MDL-009013305 at '308 (HCI).
[410] Google internal document, "Display Ad Serving: Sellside POV," (July 2022) GOOG-AT-MDL-012693796 at '826-827 (HCI).
[411] Google internal document, "EDA for Programmatic Guaranteed Deals," GOOG-AT-MDL-009013305 at '308 (HCI).
[412] Google internal document, "EDA for Programmatic Guaranteed Deals," GOOG-AT-MDL-009013305 at '308 (HCI).
[413] Google internal document, "EDA for Programmatic Guaranteed Deals," GOOG-AT-MDL-009013305 at '308 (HCI).
[414] See Appendix C Section B.10 for findings from my analysis of Google's source code on the calculation of the EDA floor price.
[415] Google internal document, "Cross Priority Ranking," (November 2011) GOOG-NE-02343690 at '691-692 (HCI). In this document, "Pa" is the highest tCPM and "MRP" is the highest vCPM.

[redacted]

143. From this process, it is evident that EDA enabled AdX to compete in real-time with guaranteed line items and remnant line items for inventory. If AdX beat the floor decided by either the price from a guaranteed line item or remnant line item, it would immediately win the impression. Figure 15 illustrates the EDA process before 2019.

[416] Google internal document, "Cross Priority Ranking," (November 2011) GOOG-NE-02343690 at '692 (HCI).

[redacted]

144. Google stated that EDA enables AdX buyers to bid on more DFP impressions and access more inventory.[418] However, EDA still presented some limitations for publishers. For example,

[417] Google internal document, "Enhanced Dynamic Allocation," (November 6, 2017) GOOG-DOJ-AT-02368104 at '106 (HCI).
[418] Google internal document, "Launch First Price Auction and Unified Pricing Rules," GOOG-DOJ-AT-00599602 at '607 (HCI).

Google acknowledged that publishers may not get the highest price that all other demand sources (such as guaranteed and remnant) might be willing to pay for the inventory.[419] This was because AdX competed for impressions using real-time bids while guaranteed and remnant line items competed using static bids with tCPM values, which were calculated by DFP using information such as historical bids and campaign progress, and vCPM values, which as discussed in Section VI.B incorporates estimates from publishers. As a result, the tCPM and vCPM values may not represent what these demand sources might have paid for the impression if they were allowed to bid in real-time. Publishers would lose out on revenue in situations where a third-party demand source would bid above its historical average CPM, such as when remarketing high bids.[420]

A. Publishers cannot disable Enhanced Dynamic Allocation

145. There was no straightforward way for publishers to disable or turn off EDA. At the time of EDA's initial launch, Google stated that for publishers "[t]he default is EDA on, all new networks have it on."[421] Due to the way EDA was designed, enabling publishers to opt out of EDA without losing access to certain planned features, such as programmatically transacting guaranteed line items,[422] would require additional engineering logic added to the AdX auction.[423] However, Google also states that implementing such accommodations was "certainly not impossible."[424]

146. The only way EDA could be disabled was through an internal Google system called ICS, which was used by Google engineers to view and modify a publisher's setup configurations.[425] This system was not accessible to publishers directly.

147. Some publishers opted out of EDA for some time during its initial launch and rollout.[426] Around the time of EDA's initial launch in 2014, [redacted] publishers had opted out; by November 2015 there were [redacted] Publishers that opted out of EDA's initial launch included [redacted],

[419] Google internal document, "Comms Doc: Header Bidding – Work in Progress," (August 2016) GOOG-NE-11797719 at '724 (HCI).
[420] Google internal email, "Re: EDA - how valuable is it to us?," GOOG-DOJ-15432462 at '463 (HCI).
[421] Google internal email, "Re: EDA rollout plan," GOOG-DOJ-14141075 at '076 (HCI).
[422] Project Jordan was an internal name for a feature that allowed publishers to transact guaranteed line items programmatically. [redacted] Deposition, (May 2, 2024) at 462:21-463:4.
[423] Google internal email, "Re: EDA rollout plan," GOOG-DOJ-14141075 at '075 (HCI).
[424] Google internal email, "Re: EDA rollout plan," GOOG-DOJ-14141075 at '075 (HCI).
[425] "The default is EDA on, all new networks have it on. It can be turned off in ICS, but we don't want to mention it as an option." Google internal email, "Re: EDA rollout plan," GOOG-DOJ-14141075 at '076 (HCI); [redacted] Deposition, (May 2, 2024) at 459:13-25.
[426] [redacted] Deposition, (May 2, 2024) at 455:7-456:22.
[427] Google internal document, "[OLD] - Meeting Notes - DRX Indirect Commercialization," GOOG-TEX-00971457 at '586 (HCI).

[redacted]. [428] Google transitioned all publishers to EDA by 2016.

148. At present, publishers are still unable to opt out of EDA within the GAM interface.[429] If a publisher wished to use AdX without EDA, they could do so with AdX tags;[430] while this offers publishers a way to circumvent EDA, as discussed in Section IV.C, AdX tags have limited functionality compared to GPT tags. Alternatively, publishers using GAM could disable AdX for a single impression by configuring GAM and AdX settings to exclude AdX from the impression's sales process.[431]

B. Before 2019, Last Look incorporated the best remnant line item's vCPM into the AdX auction floor price

149. As discussed in Section VII, one of the steps in EDA was selecting the remnant line item with the highest vCPM. This vCPM was used to inform the AdX auction price floor by comparing it to the highest tCPM from a guaranteed line item. The process of informing the AdX auction price floor with the highest vCPM was known as Last Look.

150. Last Look and the incorporation of the best remnant line item's vCPM into the AdX auction floor price proceeded in the following steps:

151. As discussed in Section VII, DFP selected the remnant line item with the highest vCPM.[432] Generally, remnant line items represent information on non-guaranteed ad campaigns, as discussed in Section IV.A. However, starting in 2014 remnant line items could also be used to represent bids from third-party exchanges in first-price auctions outside of Google's ad stack.[433] To bid in such an auction, third-party exchanges and networks used non-Google technologies such

[428] Google internal workbook, "EDA Enhanced Dynamic Allocation - Temp," GOOG-TEX-00055792 (HCI).
[429] Google internal document, "Responses to Questions 1, 4-25, 28-36, and 39-52 of the Autorite de la Concurrence's Request for Information dated 23 July 2019 Case No. 19/0030F," (July 23, 2019) GOOG-DOJ-05782415 at '437 (CI).
[430] Google document, "Responses to Questions 1, 4-25, 28-36, and 39-52 of the Autorite de la Concurrence's Request for Information dated 23 July 2019 Case No. 19/0030F," (July 23, 2019) GOOG-DOJ-05782415 at '437 (CI).
[431] Google document, "Responses to Questions 1, 4-25, 28-36, and 39-52 of the Autorite de la Concurrence's Request for Information dated 23 July 2019 Case No. 19/0030F," (July 23, 2019) GOOG-DOJ-05782415 at '438 (CI).
[432] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '489 (HCI); See Appendix C Section B.10 for findings from my analysis of Google's source code on the calculation of vCPM in EDA.
[433] Google internal document, "First-price bidding," GOOG-TEX-00949710 at '713 (HCI).

as Header Bidding.[434] The winning bid from the remnant line item, *e.g.*, a bid from Header Bidding, would be sent to DFP and matched with a remnant line item.[435] Header Bidding is discussed in detail in Section VIII.

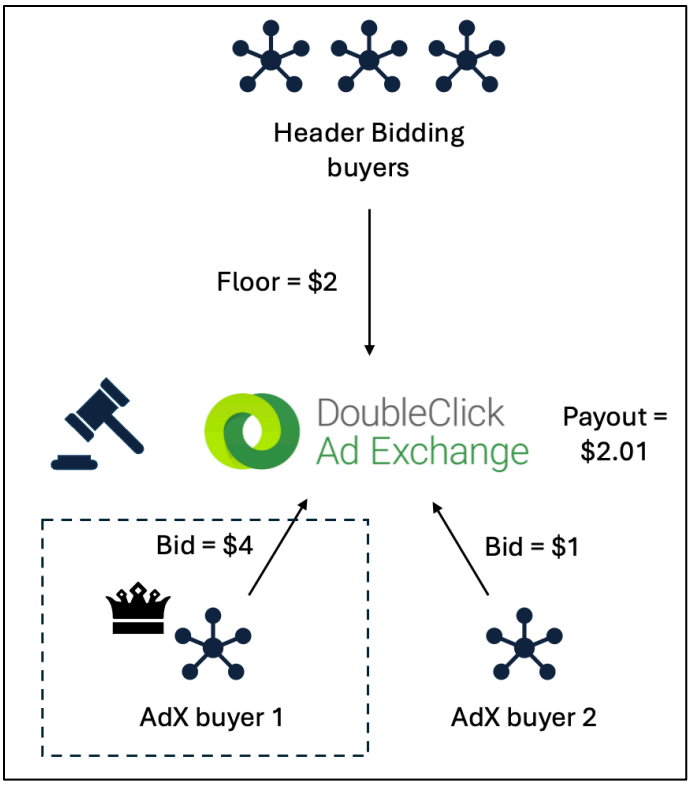
1) The highest vCPM was compared to the highest tCPM from a guaranteed line item to inform the AdX auction price floor, as discussed in Section VII.

2) AdX then ran a modified second-price auction among its buyers using the price floor. The auction outcomes are described in Section VII.

152. Thus, Last Look incorporated third-party buyers' bids by receiving auction results from external sources such as Header Bidding and used them to floor AdX's own auction. This provided AdX buyers with visibility into third-party buyers' prices before the AdX buyers submitted their own bids. This led to situations where AdX won an auction it would have otherwise lost, absent Last Look. Consider a simplified example where third-party buyers bid for an impression in a first-price auction through Header Bidding, and the winning bid of this auction is $2. This bid gets passed into DFP and is matched with a remnant line item. Suppose this remnant line item has the highest vCPM. Following Last Look, if this vCPM was greater than the highest tCPM of a guaranteed line item, then the $2 vCPM was passed to AdX as the price floor. If the AdX auction had two buyers, with the first buyer bidding $4 and the second buyer bidding $1, then the first AdX buyer would win the auction because its bid was higher than both the second AdX buyer and the price floor. Moreover, the winning AdX buyer would only pay a cent above the price floor, even though it was willing to pay more. This scenario is shown in Figure 16 below.

[434] Google internal document, "First-price bidding," GOOG-TEX-00949710 at '713 (HCI).
[435] Google internal document, "When the game changes: How HB affects Yield management in DRX," GOOG-AT-MDL-000993446 at '458, '478 (CI).

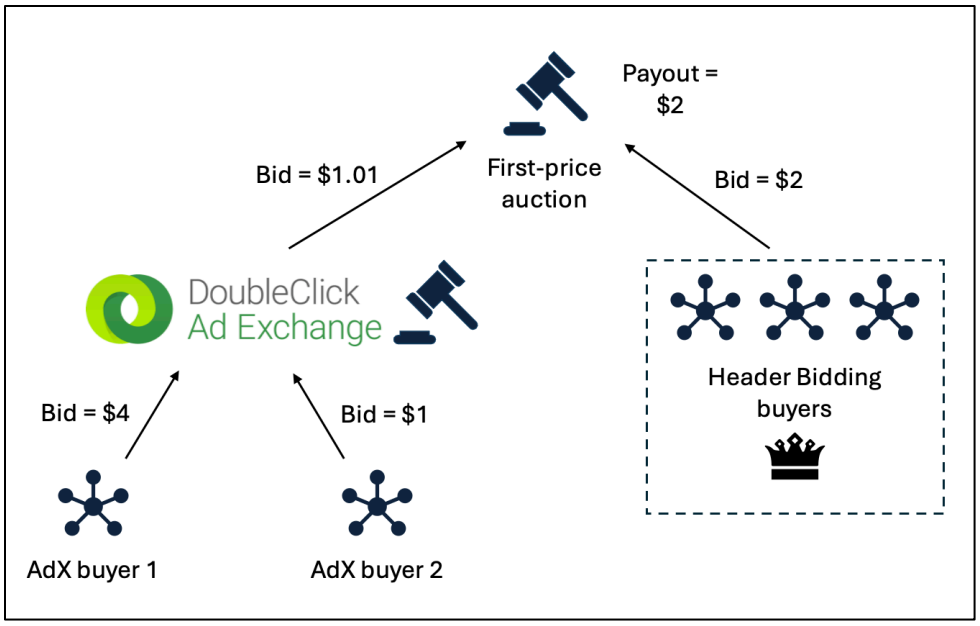
Figure 16: AdX winning auction with Last Look[436]



153. However, absent Last Look, the result of AdX's own auction may have competed in real-time against the result of the Header Bidding auction by third-party buyers. Then AdX's second-price bid, $1, would compete against Header Bidding's first-price bid, $2, and AdX would lose. AdX would effectively be unable to use information from third-party exchanges in Header Bidding in its own auction. This scenario is shown in Figure 17 below.

[436] Google internal document, "First-price bidding," GOOG-TEX-00949710 at '713 (HCI).

Figure 17: AdX losing auction without Last Look[437]



154. However, there was one exception: Last Look did not use bids submitted by third-party buyers using a Google program called Exchange Bidding to inform the AdX auction price floor. As discussed in detail in Section IX, Exchange Bidding was Google's response to Header Bidding and allowed third-party exchanges to compete in real-time alongside AdX. By February 2017, four months before Google launched the Exchange Bidding open beta for all publishers using DFP,[438] Google stopped using bids from Exchange Bidding buyers to calculate the EDA floor price.[439] Thus, AdX had a "Last Look" over Header Bidding bids but not Exchange Bidding bids.

155. In fact, when Exchange Bidding was initially launched, DFP sent Exchange Bidding participants the EDA floor price and the best remnant price to inform Exchange Bidding auctions.[440] Thus, not only did Google use Exchange Bidding buyers' bids in non-Google auctions to floor AdX auctions, but Google also provided Exchange Bidding buyers information on bids from non-Google (Header Bidding) auctions.

[437] Google internal document, "First-price bidding," GOOG-TEX-00949710 at '717 (HCI).
[438] Cox, S., "Announcing Exchange Bidding open beta," (June 8, 2017) https://blog.google/products/admanager/announcing-exchange-bidding-open-beta/. Accessed May 23, 2024.
[439] See Appendix C Section B.11 for findings from my analysis of Google's source code on the removal of last look over Exchange Bidding buyers.
[440] Google internal document, "1st Price Migration," GOOG-DOJ-28243636 at '640 (CI).

C. From 2019 onwards, Google removed Last Look from Enhanced Dynamic Allocation after transitioning to first-price auctions

156. In 2019, Google transitioned from running second-price auctions in AdX to running "unified" first-price auctions.[441] In doing so, Google stated that "no price from any of a publisher's non-guaranteed advertising sources, including non-guaranteed line item prices, will be shared with another buyer before they bid in the auction," effectively removing Last Look from EDA.[442] This meant that the remnant line item vCPMs would no longer be used to floor the AdX auction.[443]

157. After removing Last Look, the EDA process occurs as follows:

1) [redacted].[444]

2) [redacted]."[446]

[441] Bigler, J., "An update on first price auctions for Google Ad Manager," (May 10, 2019) https://blog.google/products/admanager/update-first-price-auctions-google-ad-manager/. Accessed May 30, 2024.
[442] Bigler, J., "An update on first price auctions for Google Ad Manager," (May 10, 2019) https://blog.google/products/admanager/update-first-price-auctions-google-ad-manager/. Accessed May 30, 2024.
[443] "The reserve price is at least the maximum of the temporary CPM calculated by Ad Manager for the best eligible guaranteed line item or the floor price configured by the publisher (as may be adjusted, at the publisher's option, by various Ad Manager optimizations). The reserve price is not set by either the value CPMs of remnant line items that are competing for the impression." Google, "How Open Bidding works," https://support.google.com/admanager/answer/7128958. Accessed May 23, 2024.
[444] "The reserve price for Ad Exchange ads is at least the temporary CPM from [the best guaranteed line item]." Google, "How we decide which ad is served," https://support.google.com/admanager/answer/11204312. Accessed May 23, 2024.
[445] Google, "How we decide which ad is served," https://support.google.com/admanager/answer/11204312. Accessed May 23, 2024; Google, "About campaign goal types," https://support.google.com/admob/answer/9152820. Accessed May 23, 2024; [redacted] Deposition, (May 2, 2024) at 74:22-76:5.
[446] Google, "How we decide which ad is served," https://support.google.com/admanager/answer/11204312. Accessed May 23, 2024.

3) [redacted]

4) [redacted].[450]

5) [redacted].

158. I understand that Enhanced Dynamic Allocation is still in use today.[452] The dynamics of the AdX first-price auction are discussed further in Section XIV.

VIII. HEADER BIDDING ALLOWS PUBLISHERS TO OFFER THEIR AD INVENTORY TO MULTIPLE EXCHANGES SIMULTANEOUSLY

159. This section discusses Header Bidding in detail. The section covers Header Bidding's use cases within the ad serving system, how Header Bidding is implemented at a technical level, and how data flows between publishers and advertisers under Header Bidding.

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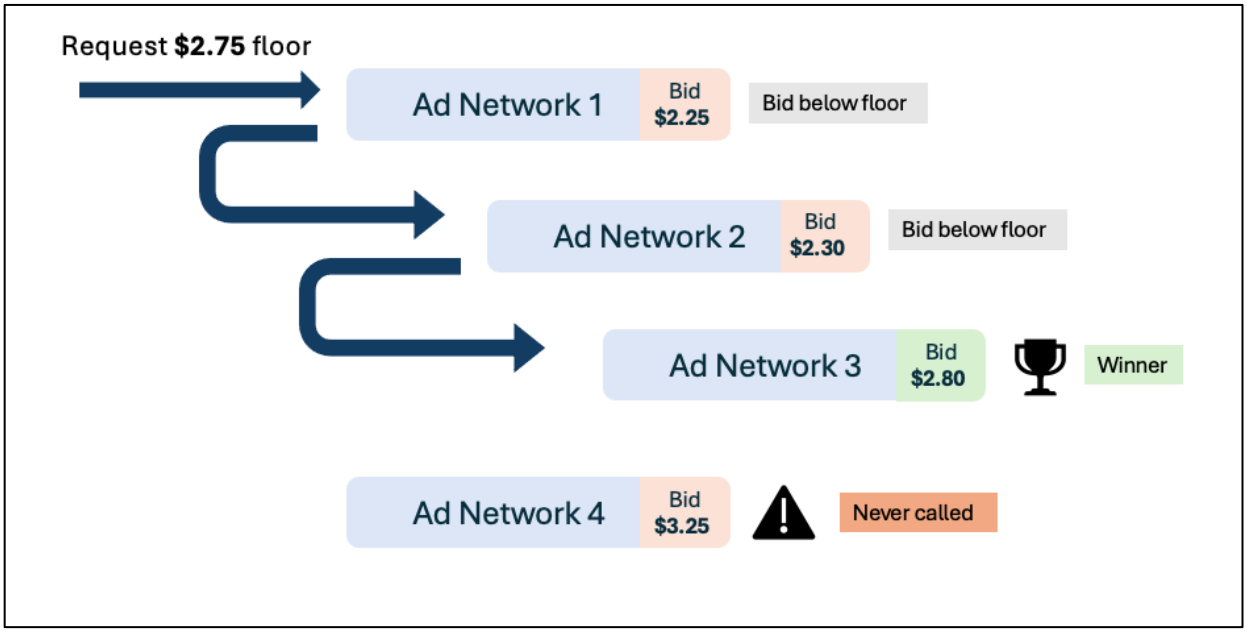
[447] Google, "How we decide which ad is served," https://support.google.com/admanager/answer/11204312. Accessed May 23, 2024.
[448] Google, "How we decide which ad is served," https://support.google.com/admanager/answer/11204312. Accessed May 23, 2024.
[449] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 11. Cox, S., "Announcing Exchange Bidding open beta," (June 8, 2017) https://blog.google/products/admanager/announcing-exchange-bidding-open-beta/. Accessed May 23, 2024.
[450] Google, "How we decide which ad is served," https://support.google.com/admanager/answer/11204312. Accessed May 23, 2024.
[451] Google, "How we decide which ad is served," https://support.google.com/admanager/answer/11204312. Accessed May 23, 2024; Google, "How Open Bidding works," https://support.google.com/admanager/answer/7128958. Accessed May 24, 2024.
[452] [redacted] Deposition, (May 2, 2024) at 77:11-13.

A. Header Bidding solicits demand across multiple supply-side platforms and resolves technical challenges of waterfall auctions

160. As discussed in Section VI.A, ad auctions were originally conducted using a "waterfall" approach, a publisher's line items for an impression would be sequentially passed from demand source (*i.e.*, demand-side platforms, ad networks, and ad exchanges) to demand source until the ad server received satisfactory bids for the impression.[453] The sequential order of the demand sources was determined using factors such as average historic performance for the publisher or a pre-negotiated price with the demand source: in other words, demand sources that produced better bids for publishers were placed earlier in the waterfall.[454] However, also discussed in Section VI.A, waterfall auctions came with several technical drawbacks, such as potential latency issues.[455] Figure 18 below depicts the waterfall auction process.

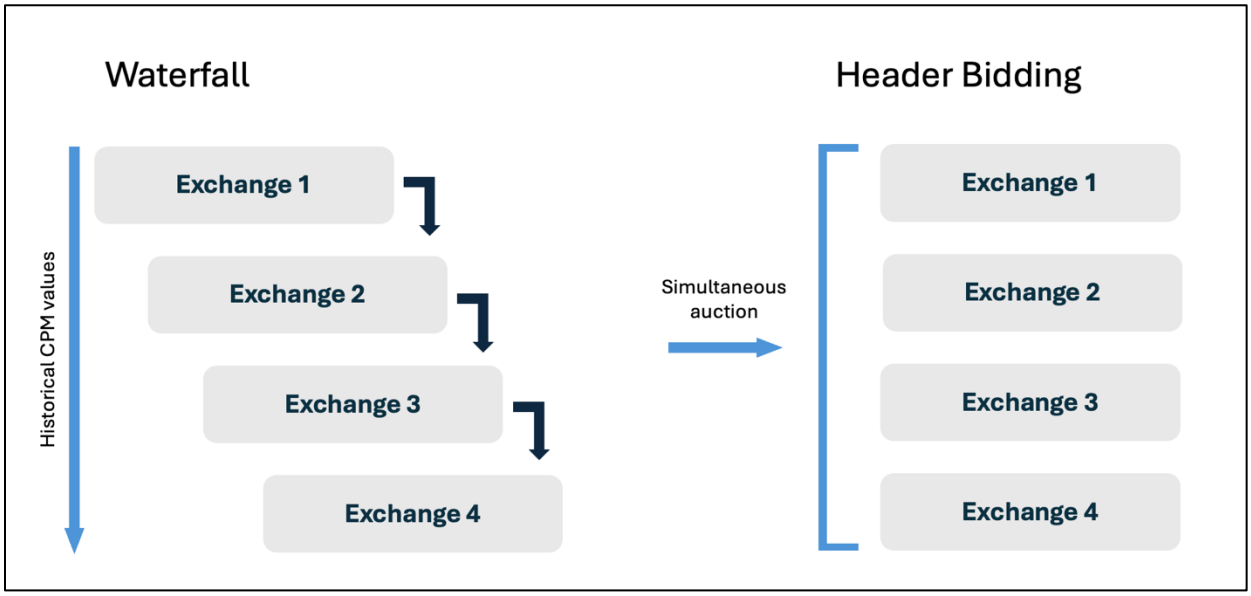
Figure 18: Waterfall auction process[456]



[453] Google internal document, "Mediation and Exchange Bidding in DRX," (October 18, 2017) GOOG-AT-MDL-001110980 at '981 (CI); Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '878-879 (HCI).
[454] Google internal document, "Clearing Up Misconceptions About Google's Ad Tech Business," (May 5, 2020) GOOG-NE-10780865 at '878-879 (HCI); Google internal document, "Mediation and Exchange Bidding in DRX," (October 18, 2017) GOOG-AT-MDL-001110980 at '982 (CI).
[455] [redacted] Deposition, (April 26, 2024) at 107:17-24.
[456] Google internal document, "Ad Manager Ecosystem 101," GOOG-AT-MDL-001004706 at '731 (HCI).

161. The introduction of Header Bidding in 2014 helped resolve the technical challenges of waterfall auctions.[457] Instead of passing through ad networks or exchanges one-by-one, Header Bidding allows demand sources to simultaneously bid on an impression before the impression is sold from the publisher's ad server.[458] Because all demand sources participating in Header Bidding bid in real-time, the ad server would be able to select the winner based on the highest bid, instead of the buyers' historical performances. Figure 19 below shows how Header Bidding enabled buyers to bid in parallel.

Figure 19: Sequential waterfall auctions compared to parallel Header Bidding auctions[459]



162. Prior to 2019, the only exceptions to parallel bidding were AdX and third-party buyers that were allowed to bid into AdX. This is because, as discussed in B, the winning Header Bidding bid that was sent to DFP was used to inform the floor price of the AdX auction due to Last Look, before the AdX auction even occurred. From 2019 onwards, Header Bidding could compete in real-time with AdX in a unified auction, as discussed in Sections VII.C.

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[457] "I started calling it Header Bidding in 2014 — right from the beginning." Digiday, "'An ad tech urban legend': An oral history of how Header Bidding became digital advertising's hottest buzzword," (June 16, 2017) https://digiday.com/media/header-bidding-oral-history/. Accessed May 23, 2024. "I think that what led to the creation of Header Bidding was this innovation of auction of auctions. And based on the way that the ad server was built, Header Bidding was a crude way to be able to support an auction of auctions." [redacted] Deposition, (April 26, 2024) at 104:1-7.

[458] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '845-846 (HCI).

[459] Google internal document, "Mediation and Exchange Bidding in DRX," (October 18, 2017) GOOG-AT-MDL-001110980 at '993 (CI).

163. For publishers using Google Ad Manager (GAM), Header Bidding allowed publishers to get more precise yields from third-party exchanges and networks. This was because prior to Header Bidding, only AdX demand sources were able to compete with real-time CPMs in an AdX auction, as discussed in Section VI.[460] With Header Bidding, real bids from third-party exchanges and networks could compete with AdX for inventory. The difference between the estimated CPM and the real-time CPM could be substantial, so Header Bidding helped publishers get more accurate bids.[461]

164. The next section will discuss Header Bidding's technical implementation in greater detail.

B. Header Bidding is implemented as code in a publisher's own webpage

165. Publishers implement Header Bidding by inserting code into their own webpages. Rather than write their own proprietary code to manage different demand sources, evaluate bids, and communicate with ad servers, publishers implement Header Bidding using packaged code known as "wrappers" or "frameworks" from third-party providers.[462] An example of a Header Bidding wrapper provider is Prebid, a widely used, free, and open-source Header Bidding software product.[463] The following sections further discuss how Header Bidding is implemented for a webpage.

a) HTML, CSS, and JavaScript are the building blocks of a webpage

166. Publishers insert the Header Bidding wrapper into the code that represents the publisher's webpage. To understand how this is done, consider the construction of a webpage. Webpages are generally constructed with code written in three languages: HTML, CSS, and JavaScript.

[460] Google internal document, "PRD: Real-time YM with Header Container," GOOG-AT-MDL-008236563 at '563, '566 (CI).
[461] "One of the core values of DRX has been the real-time nature of AdX competing with both direct and remnant line items. In contrast other demand sources, such as buyers and exchanges, instead compete using an average value. The difference between the average CPM and the real-time value of a query/cookie could be additional yield. With publishers constantly looking for incremental yield, the potential uplift from real-time pricing has been quite attractive." Google internal document, "PRD: Real-time YM with Header Container," GOOG-AT-MDL-008236563 at '563, '566 (CI).
[462] Zaiceva, A., Setupad, "Header Bidding vs Waterfall | Differences Explained," (July 13, 2021) https://setupad.com/blog/header-bidding-vs-waterfall/. Accessed May 23, 2024.
[463] Prebid, "Introduction to Prebid," https://docs.prebid.org/overview/intro.html. Accessed May 23, 2024.

167. HTML is the standard markup language used for displaying documents such as webpages in a web browser and defines the structure of the webpage's content.[464] HTML uses various elements called tags to structure content. Some examples of HTML tags include:[465]

1) `head` tag: Contains metadata about the webpage, such as the webpage's title, scripts, and styling.

2) `body` tag: Contains the content of the webpage, such as text or images.

3) `header` tag: Contains introductory and navigational content for a webpage, such as logos, titles, or navigational links.

4) `script` tag: Contains executable code that is run when the browser processes the tag.

5) `div` tag: A generic tag used to organize pieces of content.

6) `p` tag: Contains a paragraph, which in the context of HTML, refers to any structural grouping of related content, such as images.

168. CSS is a language that visually styles HTML elements.[466] For example, CSS code can change the font size and color of a paragraph of text or specify the location on the webpage for an image or other piece of content. CSS code does this by specifying an HTML tag, properties of that tag, and the values for each property. For example, for an HTML `p` tag enclosing a paragraph of text, the CSS code file might specify the color and paragraph width as properties and set the paragraph's color to red and width to 500 pixels.

169. JavaScript is a programming language that can be used to add interactivity to a website, such as games, animated graphics, or applications.[467] JavaScript is widely used, and developers often create third-party frameworks, libraries, and application programming interfaces (APIs) for other developers to use to add specialized functionalities to their webpages. JavaScript code can

[464] Mozilla, "HTML basics," https://developer.mozilla.org/en-US/docs/Learn/Getting_started_with_the_web/HTML_basics. Accessed May 23, 2024.
[465] Mozilla, "HTML elements reference," https://developer.mozilla.org/en-US/docs/Web/HTML/Element. Accessed May 23, 2024.
[466] Mozilla, "CSS basics," https://developer.mozilla.org/en-US/docs/Learn/Getting_started_with_the_web/CSS_basics. Accessed May 23, 2024.
[467] Mozilla, "JavaScript basics," https://developer.mozilla.org/en-US/docs/Learn/Getting_started_with_the_web/JavaScript_basics. Accessed May 23, 2024.

be integrated into a webpage's HTML code using the `script` tag. The `script` tag contains executable code stored in a separate JavaScript code file, or the executable code can be written into the HTML file itself.[468]

170. When a browser loads the webpage, it reads a file containing HTML code defining the structure of the webpage and any associated CSS and JavaScript code from top to bottom and executes any JavaScript code in that order.[469] Thus, the HTML file also communicates the order in which JavaScript code should be executed.

b) Header Bidding is implemented as JavaScript code included in the HTML of a webpage

171. Header Bidding wrappers are JavaScript code libraries that run in the browser.[470] Consider a basic example by Prebid that provides the HTML for a webpage that uses the Header Bidding wrapper Prebid.js and integrates with Google Ad Manager (GAM) ad slots.[471] A portion of this code is shown in Figure 20 below.

[468] "Used to embed executable code or data; this is typically used to embed or refer to JavaScript code." Mozilla, "HTML elements reference," https://developer.mozilla.org/en-US/docs/Web/HTML/Element. Accessed May 23, 2024.
[469] "The reason the instructions (above) place the <script> element near the bottom of the HTML file is that the browser reads code in the order it appears in the file. If the JavaScript loads first and it is supposed to affect the HTML that hasn't loaded yet, there could be problems. Placing JavaScript near the bottom of an HTML page is one way to accommodate this dependency." Mozilla, "JavaScript basics," https://developer.mozilla.org/en-US/docs/Learn/Getting_started_with_the_web/JavaScript_basics. Accessed May 23, 2024.
[470] "Prebid.js is a JavaScript library that runs in the browser, and is the core product of the Prebid suite. It supports multiple formats including display, video, and native, and provides a simple process for Header Bidding that can be ramped up to fit the complexity of your needs." Prebid, "Introduction to Prebid," https://docs.prebid.org/overview/intro.html. Accessed May 23, 2024.
[471] Prebid, "Basic Prebid.js Example," https://docs.prebid.org/dev-docs/examples/basic-example.html. Accessed May 23, 2024.

Figure 20: Webpage code for loading Prebid.js and GPT libraries and defining ad units[472]

```
<link rel="icon" type="image/png" href="/favicon.png">
<script async src="//www.googletagservices.com/tag/js/gpt.js"></script>
<script async src="//cdn.jsdelivr.net/npm/prebid.js@latest/dist/not-for-prod/prebid.js"></script>
<script>
    var div_1_sizes = [
        [300, 250],
        [300, 600]
    ];
    var div_2_sizes = [
        [728, 90],
        [970, 250]
    ];
    var PREBID_TIMEOUT = 1000;
    var FAILSAFE_TIMEOUT = 3000;

    var adUnits = [
        {
            code: '/19968336/header-bid-tag-0',
            mediaTypes: {
                banner: {
                    sizes: div_1_sizes
                }
            },
            bids: [{
                bidder: 'appnexus',
                params: {
                    placementId: 13144370
                }
            }]
        },
```

172. At the beginning of the webpage HTML, the code `<script async src="//cdn.jsdelivr.net/npm/prebid.js@latest/dist/not-for-prod/prebid.js"></script>` adds a file containing the Prebid.js Header Bidding module to the webpage. Similarly, the code `<script async src="//www.googletagservices.com/tag/js/gpt.js"></script>` tells the browser to add a file containing code for Google Publisher Tag (GPT).[473]

173. Farther down the page, the JavaScript code defines a variable `adUnits` which specifies the ad units available on the webpage, as well as the demand sources that are allowed to bid on each

[472] Prebid, "Basic Prebid.js Example," https://docs.prebid.org/dev-docs/examples/basic-example.html. Accessed May 23, 2024.
[473] Google, "Overview of Google Publisher Tag," https://support.google.com/admanager/answer/181073. Accessed May 30, 2024.

unit. In the example below, `adUnits` specifies two ad slots[474] and allows a single demand source, AppNexus, to bid on each slot.[475] If the publisher wished to add more demand sources, such as Rubicon or Criteo, to bid on the ad unit, they would simply add another item to the bids list containing the names of allowed bidders.[476] This demonstrates the simplicity of using a third-party Header Bidding wrapper.

174. The webpage's code then tells the browser to request Header Bidding bids and then send an ad request to the ad server, such as GAM.[477] A portion of this code is shown in Figure 21 below.

[474] Prebid, "Basic Prebid.js Example," https://docs.prebid.org/dev-docs/examples/basic-example.html. Accessed May 23, 2024.
[475] Prebid, "Basic Prebid.js Example," https://docs.prebid.org/dev-docs/examples/basic-example.html. Accessed May 23, 2024.
[476] Prebid, "Ad Unit Reference," https://docs.prebid.org/dev-docs/adunit-reference.html. Accessed May 23, 2024.
[477] Note that this figure only shows one ad slot. The full Prebid.js example code has two. Prebid, "Basic Prebid.js Example," https://docs.prebid.org/dev-docs/examples/basic-example.html. Accessed May 23, 2024.

Figure 21: Webpage code for Header Bidding bid requests and GAM ad request[478]

```
var googletag = googletag || {};
googletag.cmd = googletag.cmd || [];
googletag.cmd.push(function() {
    googletag.pubads().disableInitialLoad();
});

var pbjs = pbjs || {};
pbjs.que = pbjs.que || [];

pbjs.que.push(function() {
    pbjs.addAdUnits(adUnits);
    pbjs.requestBids({
        bidsBackHandler: initAdserver,
        timeout: PREBID_TIMEOUT
    });
});

function initAdserver() {
    if (pbjs.initAdserverSet) return;
    pbjs.initAdserverSet = true;
    googletag.cmd.push(function() {
        pbjs.que.push(function() {
            pbjs.setTargetingForGPTAsync();
            googletag.pubads().refresh();
        });
    });
}
// in case PBJS doesn't load
setTimeout(function() {
    initAdserver();
}, FAILSAFE_TIMEOUT);

googletag.cmd.push(function() {
    googletag.defineSlot('/19968336/header-bid-tag-0', div_1_sizes, 'div-1').addService(googletag.pubads());
    googletag.pubads().enableSingleRequest();
    googletag.enableServices();
});
```

175. First, automatic requesting and rendering of ad content from GAM is disabled using `googletag.pubads().disableInitialLoad()`,[479] which lets the browser make callouts to third-party exchanges and DSPs *before* calling the ad server. The ad units stored in `adUnits` are added to the Prebid auction using `pbjs.addAdUnits(adUnits)`, which, in turn, requests bids using `pbjs.requestBids()`.[480] Each Header Bidding demand source runs an auction of its own and returns a "bid response" for the highest bid, which includes the bidder name and ad ID, the

[478] Prebid, "Basic Prebid.js Example," https://docs.prebid.org/dev-docs/examples/basic-example.html. Accessed May 23, 2024.
[479] "The automatic requesting and rendering of ad content can be disabled via the PubAdsService.disableInitialLoad() method." Google, "Control ad loading and refresh," https://developers.google.com/publisher-tag/guides/control-ad-loading. Accessed May 23, 2024.
[480] Prebid, "pbjs.addAdUnits(Array|Object)," https://docs.prebid.org/dev-docs/publisher-api-reference/addAdUnits.html. Accessed May 23, 2024; Prebid, "pbjs.requestBids(requestObj)," https://docs.prebid.org/dev-docs/publisher-api-reference/requestBids.html. Accessed May 23, 2024.

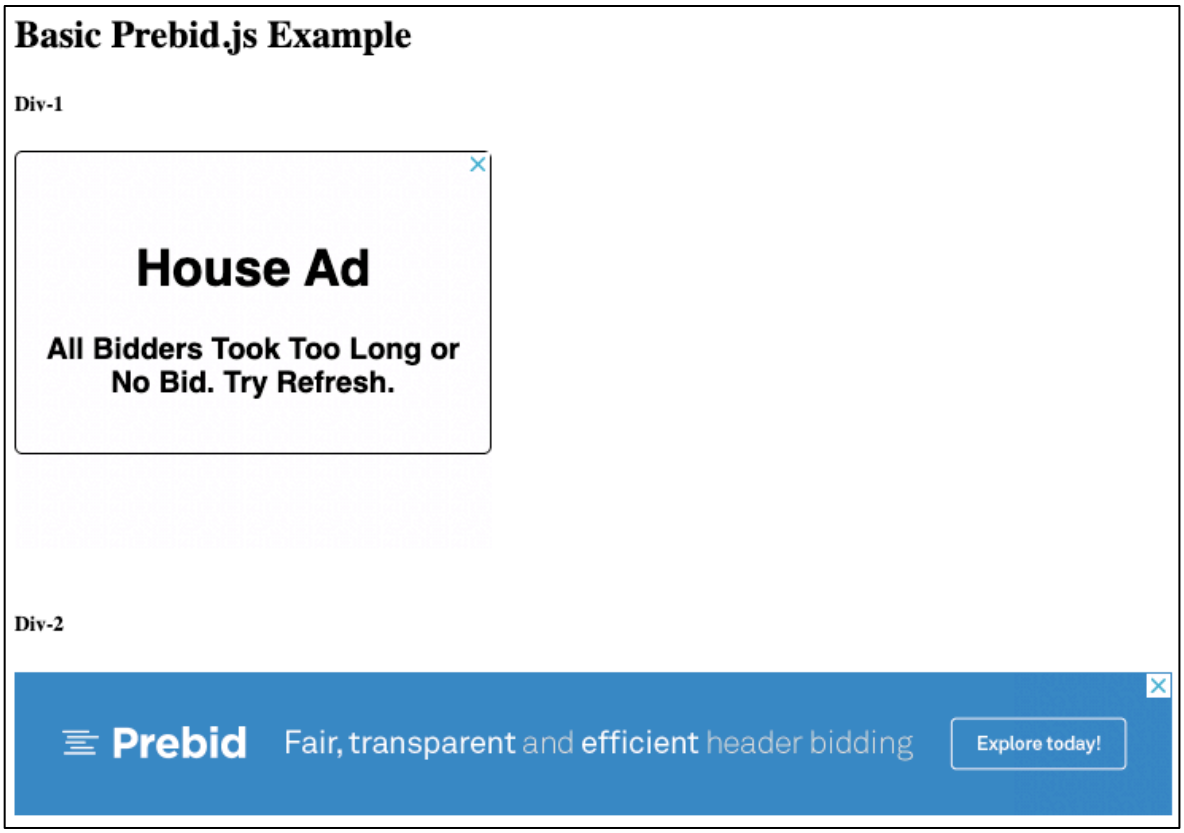
width and height of the ad, and the exact CPM of the bid or the CPM rounded to a price bucket (*e.g.*, at "low granularity" price buckets in increments of $0.50, a $1.61 bid is floored to a $1.50 price bucket instead of a $2.00 price bucket).[481] Outside of Prebid, Header Bidding demand sources can also return other responses besides the CPM of the highest bid. For example, the demand source may return a CPM range instead of a value, such as the range $1.50-2.00. The demand source may also return a "Yes/No" indicator representing whether the demand source has a satisfactory bid to return.[482]

176. Once Prebid.js has received all bids or the request times out (because no demand source returned a response within a predefined period of time), and once GPT has registered all ad slots to be sent to GAM, the function `initAdserver()` is invoked. This function calls `pbjs.setTargetingForGPTAsync()` to match ad units returned from the auction to a GPT ad slot and adds Header Bidding targeting attributes corresponding to a line item (*e.g.*, the winning bid, winning bidder, ad size, and ad format) to the ad slot so they are sent to GAM.[483] `initAdserver()` then uses `googletag.pubads().refresh()` to send a request to GAM to populate the ad slots with ad content and display the ads.[484] GAM then processes the ad request to run an auction in AdX and serve the winning ad, as discussed below in Section C.

177. Figure 22 below shows the webpage with all visual elements and advertisements loaded. Note that the top ad slot displays a House ad from Prebid because the Header Bidding request for that ad slot timed out. The bottom ad slot shows an ad delivered from a Header Bidding buyer.

[481] Prebid, "Troubleshooting Prebid.js," . Accessed May 23, 2024; Prebid, "pbjs.getBidResponses()," https://docs.prebid.org/dev-docs/publisher-api-reference/getBidResponses.html. Accessed May 23, 2024.
[482] Google internal document, "Header Bidding T1 Impact," GOOG-NE-04427230 at '239 (HCI).
[483] Prebid, "pbjs.setTargetingForGPTAsync([codeArr], customSlotMatching)," https://docs.prebid.org/dev-docs/publisher-api-reference/setTargetingForGPTAsync.html. Accessed May 23, 2024; Prebid, "Key Values," https://docs.prebid.org/adops/key-values.html. Accessed May 23, 2024.
[484] "The PubAdsService.refresh() method is used to populate a slot or slots with new ad content. This method can be used on slots that have yet to load any content (due to disableInitialLoad()), or to replace the contents of an already populated slot." Google, "Control ad loading and refresh," https://developers.google.com/publisher-tag/guides/control-ad-loading. Accessed May 23, 2024.

Figure 22: Prebid.js basic example after loading the webpage[485]



178. In summary, the Prebid example implements Header Bidding as JavaScript code in a webpage, and the Header Bidding auction runs before a request is sent to the publisher's ad sever. To accomplish this, a webpage implementing Header Bidding first pauses requests to the publisher's ad server. Afterwards, code from the Header Bidding wrapper requests bids from other demand sources first, runs an auction to determine the winning bid, and adds the winning bid, winning bidder, and other information to the ad slot, so the results of Header Bidding are sent to the publisher's ad server. Finally, a request to the publisher's ad server is sent to populate the ad slots.

C. Google uses the results of Header Bidding as inputs into the ad serving process

179. As the Prebid example shows, for publishers using GAM the results of Header Bidding are sent to the DFP ad server, which sits within GAM, along with the publisher's request for an ad.

[485] Prebid, "Basic Prebid.js Example," https://docs.prebid.org/dev-docs/examples/basic-example.html. Accessed May 23, 2024.

Specifically, the browser passes data from Prebid in the form of "key-value pairs," which are essentially the names of variables paired with their associated values.[486]

180. Key-value pairs were an existing feature in Google's ad stack that allowed publishers to define custom targeting for line items.[487] Key-value pairs were originally designed to pass in targeting criteria such as age, gender, and page content and were not designed specifically to accommodate Header Bidding.[488] Header Bidding took advantage of Google's key-value pair feature to pass in targeting criteria such as the winning bid and bidder; this is the "core" of how Header Bidding technologies like Prebid communicate with DFP.[489] For example, Prebid may send to DFP a key-value pair (`hb_pb: 2.10`), where `hb_pb` is the bid "price bucket," which indicates that a Header Bidding bid was $2.10, and (`hb_bidder: "appnexus"`), where `hb_bidder` indicates that Header Bidding bid was submitted from AppNexus.[490]

181. The Header Bidding bids usually correspond to remnant line items in GAM (*e.g.*, Price Priority),[491] though a small portion of Header Bidding bids are mapped to Standard or Sponsorship line items.[492,493] When Header Bidding bids are mapped to Standard or Sponsorship line items, AdX will not always compete because a backfill call may not be sent to AdX for guaranteed line items as discussed in Sections VI and VII.[494]

182. As part of setting up Header Bidding and integrating it with GAM, publishers create line items in GAM.[495] Publishers populate these line items with target key-value pairs from Header

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[486] Prebid, "Key Values," https://docs.prebid.org/adops/key-values.html. Accessed May 23, 2024.
[487] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '845 (HCI).
[488] Google, "Get started with key-values," https://support.google.com/admanager/answer/188092. Accessed May 30, 2024.
[489] "Prebid uses key-value pairs to pass bid information to the ad server. This puts key values at the core of how Prebid works. Without key values, Prebid would have no way of communicating with ad servers, and therefore no way to make Header Bidding part of the auction." Prebid, "Key Values," https://docs.prebid.org/adops/key-values.html. Accessed May 23, 2024.
[490] Prebid, "Key Values," https://docs.prebid.org/adops/key-values.html. Accessed May 23, 2024.
[491] See Appendix C Section B.12 for findings from my analysis of Google's source code on the implementation of Header Bidding bids.
[492] Google internal document, "Data-driven optimisations for Ad Manager," (October 2020) GOOG-AT-MDL-000009165 at '201 (CI); Google internal document, "Header Bidding & AdX Positioning," (December 2, 2015) GOOG-AT-MDL-004284449 at '461 (CI); Google internal document, "Header Bidding Observatory #2," (May 2017) GOOG-TEX-00971726 at '744 (HCI).
[493] See Appendix C Section B.13 for findings from my analysis of Google's source code on the transaction type of Header Bidding line items.
[494] Google internal document, "Header Bidding & AdX Positioning," (December 2, 2015) GOOG-AT-MDL-004284449 at '461 (CI).
[495] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '845 (HCI).

Bidding, such as `hb_pb`, `hb_bidder`, `hb_size`, and `hb_format` from Prebid.[496] For example, a particular line item might have target key-value pairs (`hb_pb: 10.50`) and (`hb_bidder: "appnexus"`). When the code on the publisher's webpage makes an ad request to GAM, it passes the Header Bidding bid key-value pairs.[497] GAM will select the most appropriate line item by comparing the key-value pairs from Header Bidding to the target key-value pairs contained in the line item, and selecting the best match.[498]

183. For instance, consider a simple example where the only key-value pairs considered are the Header Bidding bid amount, represented as `hb_pb`. Here, the publisher has configured two line items: Line Item 1 with target key-value pair (`hb_pb: 10.50`) and Line Item 2 with target key-value pair (`hb_pb: 10.00`). If the Header Bidding bid is $10.50 then GAM will match the bid to Line Item 1, and if the Header Bidding bid is $10.00 then GAM will match the bid to Line Item 2. The selected line item would then compete in the AdX auction using the line item's CPM.

184. In practice, the publisher needs to create a line item for every bid price that could be received from Header Bidding buyers, so GAM can match the Header Bidding bids to the best line items.[499] Because the number of possible bid prices is enormous, the publisher faces a tradeoff when creating line items. A publisher creating more line items can specify prices at a greater granularity, and publishers could better capture the true value of bids from Header Bidding. For example, if the publisher created line items in $0.10 increments, a $10.44 bid from Header Bidding might be matched to a line item with a $10.40 CPM; in contrast, if the publisher created line items in $0.50 increments, then the same bid might be matched to a line item with a $10.00 CPM. However, because creating line items in GAM is a manual process, managing many line items for Header Bidding can be very labor-intensive, with publisher potentially creating thousands of line items for a single Header Bidding buyer.[500] Conversely, a setup with fewer line

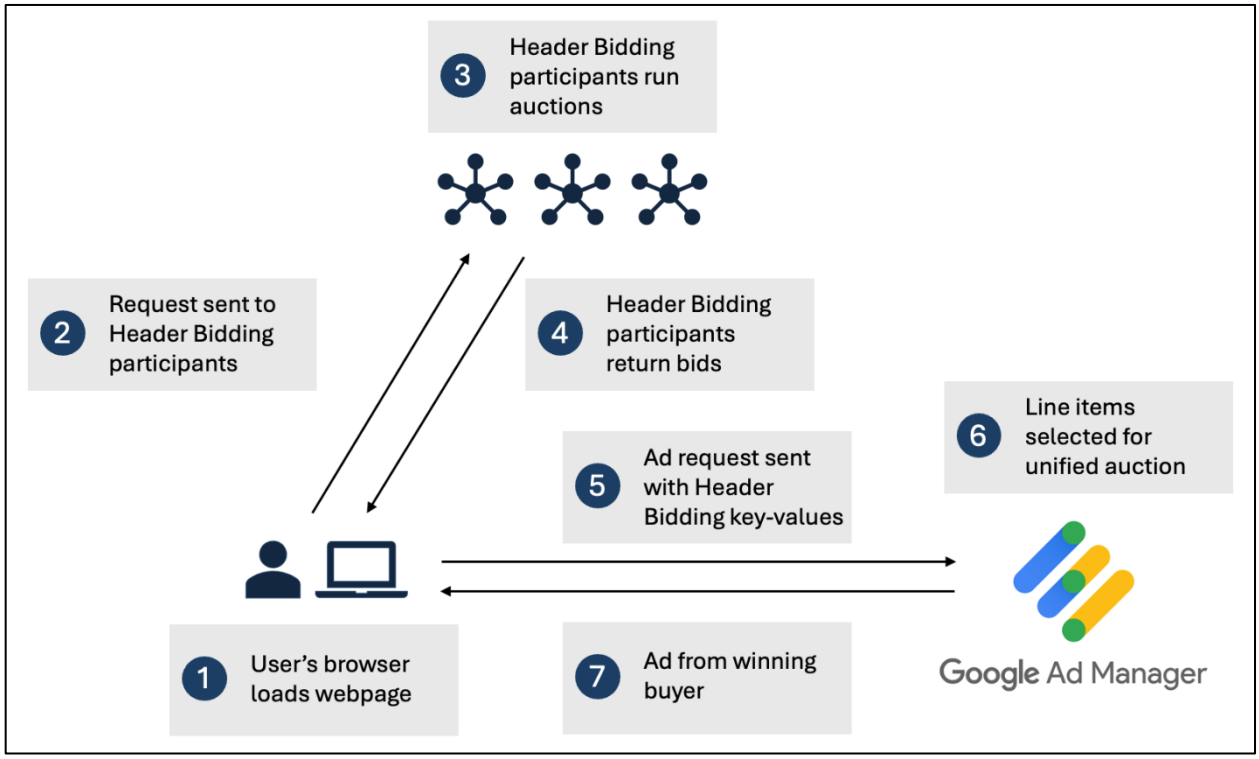
[496] "When you create your line item, you'll be targeting key-value pairs that are being sent with the ad request to the ad server. Any keys you target need to be defined in GAM before you can use them in your line items." Prebid, "Key Values," https://docs.prebid.org/adops/key-values.html. Accessed May 23, 2024.
[497] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '845 (HCI); Prebid, "Key Values," https://docs.prebid.org/adops/key-values.html. Accessed May 23, 2024.
[498] Google internal document, "When the game changes: How HB affects Yield management in DRX," GOOG-AT-MDL-000993446 at '458, '478 (CI).
[499] Prebid, "Price Granularity," https://docs.prebid.org/adops/price-granularity.html. Accessed June 4, 2024.
[500] Prebid, "Price Granularity," https://docs.prebid.org/adops/price-granularity.html. Accessed June 4, 2024; Google, "Add new line items," https://support.google.com/admanager/answer/82236?hl=en. Accessed June 4, 2024.

items means less labor and effort for the publisher, but the publisher would be specifying prices at a lesser granularity and therefore could lose money on the Header Bidding bids they receive.[501]

185. If a Header Bidding bid is the winner of the auction for an impression, GAM will return a third-party buyer tag back to the browser.[502] This third-party buyer tag is not the ad itself to be ultimately displayed on the browser, but instead represents a request to a third-party ad server that serves the Header Bidding buyer and stores the ad to be displayed.[503] When the third-party buyer tag is executed by the browser, it requests the ad to be displayed from the third-party ad server.[504]

186. Figure 23 below shows the Header Bidding workflow from start to finish.

Figure 23: Header Bidding workflow with GAM



[501] Prebid, "Price Granularity," https://docs.prebid.org/adops/price-granularity.html. Accessed June 4, 2024.
[502] Google internal document, "Header Bidding T1 Impact," GOOG-NE-04427230 at '239 (HCI).
[503] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '846 (HCI); Google, "Third-party ad serving (3PAS)," https://support.google.com/authorizedbuyers/answer/2961247. Accessed May 23, 2024.
[504] Google internal document, "Header Bidding T1 Impact," GOOG-NE-04427230 at '239 (HCI).

187. The discussion above shows how GAM can take the results of Header Bidding as input to the unified auction. Note that AdX did not directly participate in Header Bidding as a demand source. For publishers that did not use AdX, this meant that even with Header Bidding there was no way they could access demand sources that only bid into AdX, such as Google Ads.[505] Thus, publishers that did not use GAM and AdX had a more limited set of demand sources.

188. In conclusion, Header Bidding is a technology that enables publishers to solicit demand for impressions outside of the publisher's ad server, such as DFP within GAM. Client-side Header Bidding is implemented as JavaScript code that is run by the user's browser when it loads a webpage and gathers bids from external demand sources before a request is sent to the publisher's ad server. The publisher's ad server accounts for the results of Header Bidding in the server's own auction, and Header Bidding is treated as a line item among many other line items.

D. Different types of Header Bidding implementations are used, each with their own benefits and drawbacks

189. Publishers may set up Header Bidding in different ways. There are two main ways to set up Header Bidding: client-side and server-side. This section gives an overview of client-side and server-side Header Bidding, as well as their benefits and drawbacks.

190. Client-side Header Bidding is the most popular version of Header Bidding; it is based in the user's browser and works like a tag in a webpage's header.[506] Client-side Header Bidding proceeds in four steps:[507]

1) When the browser loads a webpage, the browser runs the JavaScript code for Header Bidding.

[505] "Google Ads, formerly AdWords, internally known as Google Display Ads (GDA) is our basic buy-side product, allowing advertisers to buy ads through Google … These ads are stored in Adgroup Server (AGS) and are served by many Google ad serving stacks." Google internal document, "AViD Serving Infrastructure 101 (Backend)," (December 18, 2023) GOOG-AT-MDL-B-005180695 at '698 (HCI).
[506] "Client-side Header Bidding remains the most popular version of the technology, and operates similarly to any tag you might find in a website's header." Taylor, R., Criteo, "Header Bidding Demystified: Client-Side vs. Server-Side," (June 13, 2022) https://www.criteo.com/blog/header-bidding-demystified-client-side-vs-server-side/. Accessed May 23, 2024.
[507] Google internal document, "Header Bidding Observatory #2," (May 2017) GOOG-AT-MDL-004300268 at '274 (CI); Taylor, R., Criteo, "Header Bidding Demystified: Client-Side vs. Server-Side," (June 13, 2022) https://www.criteo.com/blog/header-bidding-demystified-client-side-vs-server-side/. Accessed May 23, 2024.

2) The JavaScript code sends a request for bids from multiple demand sources simultaneously. Each demand source has a certain amount of time to respond with a bid before the request times out.

3) The Header Bidding JavaScript code passes information on the Header Bidding auction bids to the publisher's ad server, such as GAM. For some Header Bidding wrappers like Prebid, the publisher can specify whether they send only the winning bid or all bids.[508]

191. The publisher's ad server sends bid requests to additional demand sources through exchanges (*e.g.*, AdX), which run auctions of their own, and decides on the ad to be loaded onto the webpage, while accounting for the information from Header Bidding.

192. Based on this description, the Prebid.js implementation discussed in Section VIII.B is an example of client-side Header Bidding. Key advantages of client-side Header Bidding include the ability to specify exactly which demand sources to include and simple scalability with more demand sources:[509] as the Prebid.js example shows, adding a demand source is as simple as writing a few extra lines of code in the webpage. The Prebid.js example also shows that client-side Header Bidding requires few installation steps: the publisher simply downloads the software and selects the desired demand sources.[510] Additionally, because the entire process occurs in the user's browser, demand sources can read browser cookies to identify the user and adjust their bids to fit the user's profile.[511]

193. However, browsers such as Mozilla Firefox, Apple Safari, Brave Browser, and Google Chrome have recently begun restricting the usage of third-party cookies, which build user profiles by tracking user activity across websites; this reduces client-side Header Bidding's ability to identify users.[512]

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[508] "When you're sending the Top Price Bid to the ad server, the preceding keys are the only keys that will be sent. If you're Sending All Bids, the preceding keys will be sent, plus the same set of keys specific to each bidder, with the bidder name appended." Prebid, "Key Values," https://docs.prebid.org/adops/key-values.html. Accessed May 23, 2024.
[509] "[Pros of client-side Header Bidding:] Easier to add multiple SSPs after the first[.]" Google internal document, "Header Bidding Observatory #2," (May 2017) GOOG-AT-MDL-004300268 at '274 (CI).
[510] "To run heading [*sic*] bidding on your site with Prebid.js you need to download the Prebid.js package, including your selected bidders and adapters, and add the code to your page." Prebid, "Getting Started for Developers," https://docs.prebid.org/dev-docs/getting-started.html. Accessed May 24, 2024.
[511] "Better identity resolution thanks to the ability to use browser-based cookie syncing." Taylor, R., Criteo, "Header Bidding Demystified: Client-Side vs. Server-Side," (June 13, 2022) https://www.criteo.com/blog/header-bidding-demystified-client-side-vs-server-side/. Accessed May 23, 2024.
[512] Mills, C., Mozilla, "Saying goodbye to third-party cookies in 2024," (December 7, 2023) https://developer.mozilla.org/en-US/blog/goodbye-third-party-cookies/. Accessed May 24, 2024.

194. Additionally, because the browser handles multiple calls to demand sources and runs the Header Bidding auction, client-side Header Bidding may affect webpage loading latency.[513] Even so, this latency can be reduced or eliminated with mitigations such as using more modern networking protocols or optimizing third-party exchanges' auction code.[514]

195. The extent to which client-side Header Bidding impacts latency can also vary. For example, in 2017, Google conducted a study on the effect of client-side Header Bidding on latency by comparing versions of a publisher's webpage without using client-side Header Bidding to versions with client-side Header Bidding enabled.[515] However, Google found that the versions without client-side Header Bidding actually experienced higher latency than the versions with client-side Header Bidding and attributed a significant portion of page load times to the GPT tag.[516] This showed that client-side Header Bidding is just one of several factors that can affect webpage loading latency and may not always be the main factor.

196. An alternative to client-side Header Bidding is server-side Header Bidding. Unlike in client-side Header Bidding where the browser is responsible for managing the calls to demand sources and running the auction, in server-side Header Bidding the browser calls an external server to manage the process.[517] This allows the browser to focus on serving content, instead of having to spend additional time and resources on the Header Bidding process. Examples of server-side Header Bidding include Prebid Server (a separate product from the Prebid.js wrapper) and Amazon Transparent Ad Marketplace.[518]

197. The process of setting up server-side Header Bidding can be more complicated relative to client-side Header Bidding, because an external server needs to be hosted and managed. For

[513] "[Cons of client-side Header Bidding:] Prone to higher levels of latency and impacted user experience[.]" Google internal document, "Header Bidding Observatory #2," (May 2017) GOOG-AT-MDL-004300268 at '274 (CI); [redacted] Deposition (April 26, 2024) at 107:17-24.
[514] Aqeel, W., Bhattacherjee, D., et al., "Untangling Header Bidding Lore: Some Myths, Some Truths, and Some Hope," In: Sperotto, A., Dainotti, A., Stiller, B. (eds) Passive and Active Measurement. PAM 2020. Lecture Notes in Computer Science, vol 12048. Springer, Cham. https://doi.org/10.1007/978-3-030-44081-7_17.
[515] Google internal email, "Re: EB/ HB latency study - need two more pubs," (May 5, 2017) GOOG-DOJ-14739278 at '281 (HCI).
[516] Google internal email, "Re: Catchpoint - MailOnline URL endpoints," (February 13, 2018) GOOG-DOJ-14744242 at '252 (HCI).
[517] Google internal document, "Header Bidding Observatory #2," (May 2017) GOOG-AT-MDL-004300268 at '274 (CI); Taylor, R., Criteo, "Header Bidding Demystified: Client-Side vs. Server-Side," (June 13, 2022) https://www.criteo.com/blog/header-bidding-demystified-client-side-vs-server-side/. Accessed May 23, 2024.
[518] Prebid, "Prebid Server Overview," https://docs.prebid.org/prebid-server/overview/prebid-server-overview.html. Accessed May 24, 2024; Amazon, "Transparent Ad Marketplace," https://aps.amazon.com/aps/transparent-ad-marketplace/. Accessed May 23, 2024.

example, Prebid states that "installing [Prebid Server] is not nearly as easy as Prebid.js."[519] This is in large part because hosting an external server requires significant infrastructure, including the server itself, databases and replicas of databases, monitoring systems, load balancers to route requests, and the server-side software.[520] Prebid Server also partners with third-party managed service providers that host the external servers rather than having the publisher set up and manage their own in-house infrastructure; this is still an installation step that is not required for the client-side Prebid.js.[521]

198. The overall process of server-side Header Bidding is similar to that of client-side Header Bidding, except that some operations performed by the browser in client-side Header Bidding are delegated to the external server instead. The external server is responsible for sending requests to demand sources and returns the results of the Header Bidding auction to the browser; the browser then sends the winning bid to the publisher's ad server and makes a request for ads.[522]

199. As discussed above, server-side Header Bidding has the advantage of reducing page load latency relative to client-side Header Bidding, since the browser no longer manages calls to the demand sources. Having a server dedicated to calling demand sources also means that server-side Header Bidding can request bids from a larger pool of demand sources.[523] However, because requests to demand sources are left to the server, a publisher using server-side Header Bidding may have less transparency on how the auction is run by the server.[524] Additionally, because the auction is run on servers instead of the browser in server-side Header Bidding, demand sources

[519] Prebid, "Prebid Server Overview," https://docs.prebid.org/prebid-server/overview/prebid-server-overview.html. Accessed May 24, 2024.
[520] Prebid, "Hosting a Prebid Server Cluster," https://docs.prebid.org/prebid-server/hosting/pbs-hosting.html. Accessed May 24, 2024.
[521] "Several Prebid.org members host up-to-date server software with a global footprint, and provide tools to manage stored requests." Prebid, "Prebid Server Overview," https://docs.prebid.org/prebid-server/overview/prebid-server-overview.html. Accessed May 24, 2024.
[522] Google internal document, "Header Bidding Observatory #2," (May 2017) GOOG-AT-MDL-004300268 at '274 (CI); Taylor, R., Criteo, "Header Bidding Demystified: Client-Side vs. Server-Side," (June 13, 2022) https://www.criteo.com/blog/header-bidding-demystified-client-side-vs-server-side/. Accessed May 23, 2024.
[523] Google internal document, "Header Bidding Observatory #2," (May 2017) GOOG-AT-MDL-004300268 at '274 (CI); Taylor, R., Criteo, "Header Bidding Demystified: Client-Side vs. Server-Side," (June 13, 2022) https://www.criteo.com/blog/header-bidding-demystified-client-side-vs-server-side/. Accessed May 23, 2024.
[524] Google internal document, "Header Bidding Observatory #2," (May 2017) GOOG-AT-MDL-004300268 at '274 (CI); Taylor, R., Criteo, "Header Bidding Demystified: Client-Side vs. Server-Side," (June 13, 2022) https://www.criteo.com/blog/header-bidding-demystified-client-side-vs-server-side/. Accessed May 23, 2024.

have limited access to browser cookies for targeting purposes, causing them to "to bid less often or at lower CPMs compared to a client-side integration."[525]

200. Regardless of the implementation chosen, Header Bidding allows publishers to gather additional bids for impressions before sending a request to the ad server and allows third-party demand sources to present real-time CPM bids to compete in auctions, as opposed to average values. This results in more opportunities for publishers to maximize yield on their impressions.

IX. EXCHANGE BIDDING IS GOOGLE'S SERVER-SIDE RESPONSE TO HEADER BIDDING AND ALLOWS THIRD-PARTY EXCHANGES TO COMPETE FOR IMPRESSIONS IN REAL-TIME ALONGSIDE ADX

201. This section covers Exchange Bidding's use cases within the ad serving system, how Exchange Bidding is implemented at a technical level, and how data flows between advertisers and publishers under Exchange Bidding.

A. Google developed Exchange Bidding to rectify technical challenges with waterfall auctions and Header Bidding and to counteract Header Bidding adoption

202. After Header Bidding was introduced, Google tracked its impact and adoption by publishers that worked with Header Bidding providers.[526] Google found that some publishers believed Header Bidding kept Google's own exchange, AdX, "honest and not complacent," and that other publishers wanted Google to provide a Header Bidding solution of their own.[527] Google also saw risks in competitors perceiving Enhanced Dynamic Allocation (EDA) giving AdX an unfair advantage, Header Bidding loosening Google's control over inventory access, namely "guaranteed space,"[528] and existing implementations of Header Bidding being "set up to break EDA resulting in Google not competing in real-time."[529]

[525] Prebid, "Server-Side Header Bidding with Prebid.js," https://docs.prebid.org/dev-docs/pbsBidAdapter-video-overview.html. Accessed May 24, 2024.
[526] Google internal document, "Header Bidding T1 Impact," GOOG-NE-04427230 at '232 (HCI).
[527] Google internal document, "Header Bidding T1 Impact," GOOG-NE-04427230 at '233, '235 (HCI).
[528] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '848 (HCI).
[529] Google internal document, "PRD: Real-time YM with Header Container," GOOG-AT-MDL-008236563 at '566 (CI).

203. According to Google, Exchange Bidding aimed to resolve several technical challenges with Header Bidding:[530]

1) Exchange Bidding would eliminate the need for managing complex Header Bidding code on a webpage and numerous Header Bidding line items.

2) Exchange Bidding would allow publishers to get paid faster.

3) Exchange Bidding would make more accurate payments and would centralize reporting.

4) Exchange Bidding would reduce latency and improve user experience.

204. The next section discusses how Exchange Bidding is implemented by Google and how it integrates with the rest of GAM.

B. Exchange Bidding is a server-side solution that runs an auction with both AdX buyers and third-party buyers bidding in real-time

205. Exchange Bidding (also known as "Open Bidding" and internally known as "Jedi") is Google's server-side response to Header Bidding, in which a single bid request is sent from the publisher webpage to the ad server, which then sends bid requests to all participating bidders, including both AdX and third-party exchanges, to compete in a single real-time auction.[531]

206. Exchange Bidding does not require publishers to include specialized code on their webpages, outside of including a GPT tag that publishers would already use to communicate with GAM.[532] However, Exchange Bidding requires several contractual and logistical tasks for both publishers and third-party demand sources. Publishers must sign an addendum to their contract with AdX, create a primary AdX account that is linked to their GAM network and set as the default account for DA, and ensure they have available inventory designated using GPT.[533] Meanwhile, third-party demand sources must sign a contract with Google to participate in Exchange Bidding,

[530] Google internal document, "Data-driven optimizations for Ad Manager," (October 29, 2020) GOOG-AT-MDL-000009165 at '198 (CI).
[531] Google internal document, "[Comms Doc] – Open Bidding on Ad Manager (fka Exchange Bidding)," (August 2019) GOOG-NE-10942712 at '715 (HCI); [redacted] Deposition, (April 26, 2024) at 203:18-204:4, 213:8-16.
[532] "Requests are sent to Ad Manager using Google Publisher Tags." Google, "How Open Bidding works," https://support.google.com/admanager/answer/7128958. Accessed May 24, 2024.
[533] Google internal document, "Mediation and Exchange Bidding in DRX," (October 18, 2017) GOOG-AT-MDL-001110980 at '001 (CI); Google, "Get started with Open Bidding," https://support.google.com/admanager/answer/7128657. Accessed May 30, 2024.

pass a testing period to verify that the Exchange Bidding integration works properly, and obtain contracts with publishers and designate their GAM networks for Exchange Bidding.[534] Google states that this "handshake" ensures the publisher and third-party demand source want to work together.[535]

207. After completing the "handshake," the publisher configures Exchange Bidding directly in GAM. This involves several steps to ensure that the publisher will be able to request bids from the specified third-party demand source during Exchange Bidding:[536]

208. Create yield groups to specify the inventory the publisher wants to sell. Yield groups are treated similarly to AdX line items during auctions in the sense that both yield groups and line items call AdX to run an auction and both trigger Dynamic Allocation.[537] They have targeting that is similar to but less granular than AdX line items: for example, yield groups can support targeting types like geography or browser, but placement targeting is not supported.[538] Additionally, while AdX line items can call many different accounts, yield groups must specify or "map" which AdX and third-party exchanges to call.[539]

1) Create yield partners, which represent the third-party demand sources that compete for the specified yield groups.

2) Configure the yield partners to enable Exchange Bidding integration.

209. After the publisher configures Exchange Bidding in GAM, the publisher can now make ad requests to GAM that incorporate Exchange Bidding. To integrate Exchange Bidding, GAM takes in bids from both AdX and Exchange Bidding demand sources and hosts a "unified auction."

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[534] Google internal document, "Mediation and Exchange Bidding in DRX," (October 18, 2017) GOOG-AT-MDL-001110980 at '001 (CI); Google, "Get started with Open Bidding," https://support.google.com/admanager/answer/7128657. Accessed May 30, 2024.
[535] Google internal document, "Mediation and Exchange Bidding in DRX," (October 18, 2017) GOOG-AT-MDL-001110980 at '001 (CI).
[536] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '864-870 (HCI); Google, "Create and manage yield groups," https://support.google.com/admanager/answer/7390828. Accessed May 23, 2024.
[537] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '872 (HCI).
[538] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '872 (HCI); Google, "Create and manage yield groups," https://support.google.com/admanager/answer/7390828. Accessed May 23, 2024; Google, "Targeting types," https://support.google.com/admanager/answer/2884033. Accessed May 24, 2024.
[539] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '872 (HCI); Google, "How Open Bidding works," https://support.google.com/admanager/answer/7128958. Accessed May 23, 2024.

Google states that all participants in the unified auction compete equally for each impression on a net basis, which accounts for GAM's revenue share.[540] The unified auction process is described below in five steps:[541]

1) The browser loads the publisher's webpage containing a GPT tag, which triggers an ad request that is sent to GAM.

2) GAM uses Enhanced Dynamic Allocation to calculate an auction reserve price. The auction reserve price is sent to all AdX and Exchange Bidding demand sources participating in the auction.[542] EDA and reserve prices are explained in further detail in Section VII.

3) Simultaneously, GAM uses the publisher's yield groups to identify the yield partners representing third-party demand sources that are eligible to compete in the unified auction. GAM requests bids from each yield partner. Each yield partner uses an Exchange Bidding integration to run their own auction and return the highest bid.

4) GAM hosts a unified auction that compares the yield partner bids alongside the AdX bid and other remnant and direct line items using EDA. The unified auction is a first-price auction.

5) If an AdX demand source wins the unified auction, GAM returns the AdX demand source's ad. If an Exchange Bidding yield partner wins, GAM returns the yield partner's ad.

210. Figure 24 below shows the different end scenarios in the GAM first-price auction for AdX, Exchange Bidding, and Header Bidding.

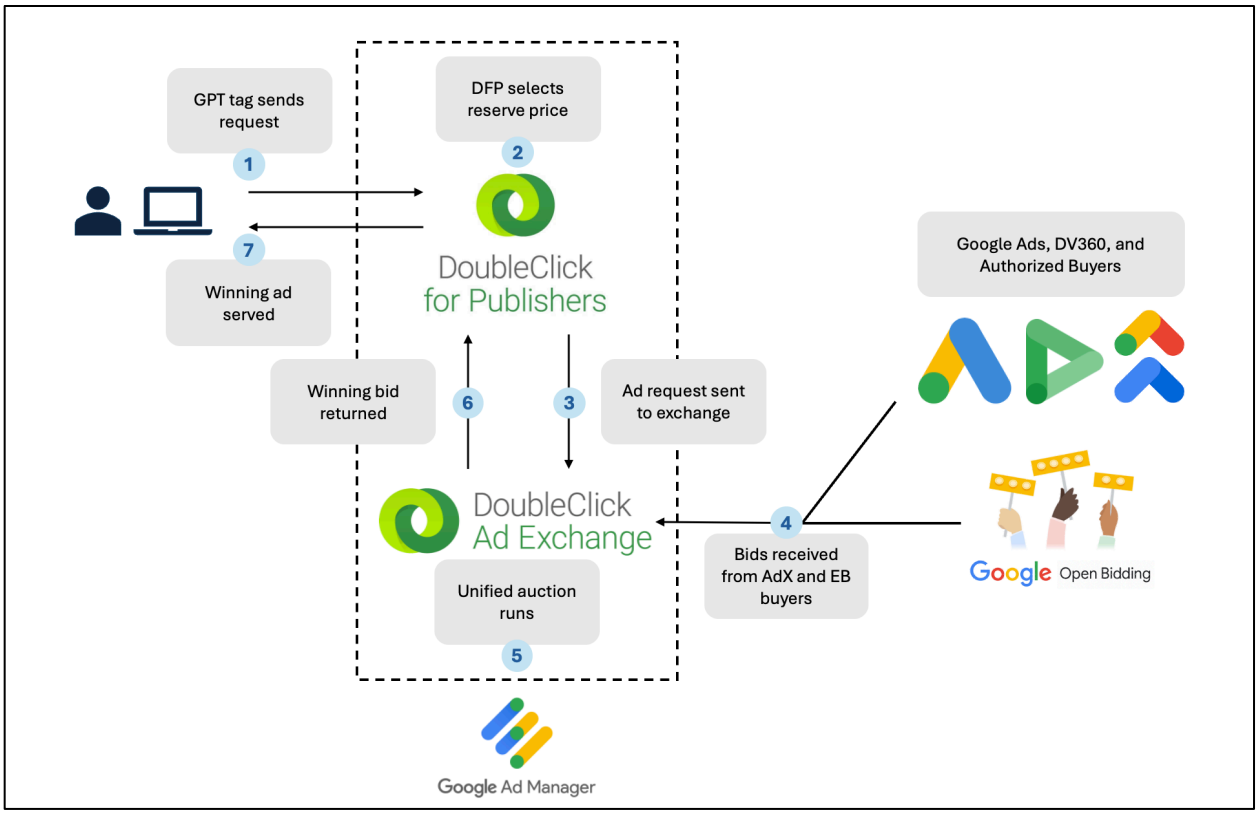
[540] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '876 (HCI).
[541] Google internal document, "Exchange Bidding Training," (August 2019) GOOG-TEX-00971841 at '876-878 (HCI); Google, "How Open Bidding works," https://support.google.com/admanager/answer/7128958. Accessed May 23, 2024.
[542] "Ad Manager sends the reserve price for the unified auction to all eligible Authorized Buyers and Open Bidding participants (including third-party exchanges or networks). The reserve price is at least the maximum of the temporary CPM calculated by Ad Manager for the best eligible guaranteed line item or the floor price configured by the publisher[.]" Google, "How Open Bidding works," https://support.google.com/admanager/answer/7128958. Accessed May 23, 2024.

Figure 24: Winning scenarios for AdX, Exchange Bidding, and Header Bidding

Bid Source	Net Bid CPM	First-Price Auction Winner	Cost Paid
Scenario 1: AdX wins			
Header Bidding	$ 5	AdX 1	$ 6
AdX 1	$ 6		
AdX 2	$ 5		
Exchange Bidding 1	$ 4		
Exchange Bidding 2	$ 5.50		
Scenario 2: Exchange Bidding wins			
Header Bidding	$ 5	Exchange Bidding 1	$ 6.25
AdX 1	$ 6		
AdX 2	$ 5		
Exchange Bidding 1	$ 6.25		
Exchange Bidding 2	$ 5.50		
Scenario 3: Header Bidding wins			
Header Bidding	$ 6.50	Header Bidding	$ 6.50
AdX 1	$ 6		
AdX 2	$ 5		
Exchange Bidding 1	$ 4		
Exchange Bidding 2	$ 5.50		

211. Figure 25 below shows the Exchange Bidding workflow.

Figure 25: Exchange Bidding workflow with GAM



212. Exchange Bidding, as a server-side solution that facilitated competition with third-party demand sources, resulted in both technical benefits and drawbacks for publishers. As discussed above in Section D, server-side solutions like server-side Header Bidding allow for lower latency and more auction participants compared to client-side solutions. However, as also discussed in Section D, server-side solutions generally have less transparency on how the external server runs the auction. This was also true for publishers using Exchange Bidding, especially if they were also using Header Bidding at the same time. For example, Google limited the information in data files about its auctions, which included:[543]

1) "Bid Data Transfer" files: These files include records of bids received by AdX and records of bids by third-party demand sources bidding through Exchange Bidding, but not bids that came from Header Bidding. These files also include bidding data such as bidder

543 [redacted]; Australian Competition & Consumer Commission, "Digital advertising services inquiry," (August 2021) https://www.accc.gov.au/system/files/Digital%20advertising%20services%20inquiry%20-%20final%20report.pdf, p. 150. Accessed May 24, 2024.

name, bidder price, and whether the bid won or lost. Information about the ad impression, such as the price at which the impression was sold, is not included.

2) "Impression Data Transfer" files: These files include information about the price at which an impression was sold, and the bids of Header Bidding demand sources.

213. Before September 2019, publishers that wished to compare the performance of all bids and buyers (*i.e.*, AdX buyers, Exchange Bidding buyers, and Header Bidding buyers) for a particular impression could do so by matching the data in "Bid Data Transfer" files and "Impression Data Transfer" files. However, in September 2019 Google prevented publishers from matching these files as part of its transition to first-price unified auctions, citing the need to "prevent bid data from being tied to individual users[.]"[544] This consequently made it more difficult for publishers to compare Google's demand sources with other demand sources, as I explain below.[545]

214. Google prevented matching by changing some of the data fields in the Bid Data Transfer files. One field, "KeyPart," was a unique value that could be used to match with data transfer files that might contain user data from bidders, such as the user's device, browser, cookies, or unique identifier.[546] Another field, "TimeUsec2," was a timestamp for an auction that was recorded at the microsecond level.[547] Before September 2019, the combination of the KeyPart and TimeUsec2 fields could uniquely identify all information about an auction (*e.g.*, bids, bidders, and impressions) across the Bid Data Transfer files and Impression Data Transfer files. Subsequently, Google made changes to both fields in the Bid Data Transfer files such that matching was no longer possible:[548]

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[544] Bigler J., "Rolling out first price auctions to Google Ad Manager partners," (September 5, 2019) https://blog.google/products/admanager/rolling-out-first-price-auctions-google-ad-manager-partners/. Accessed May 23, 2024.
[545] Australian Competition & Consumer Commission, "Digital advertising services inquiry," (August 2021) https://www.accc.gov.au/system/files/Digital%20advertising%20services%20inquiry%20-%20final%20report.pdf, p. 150. Accessed May 24, 2024.
[546] Google internal document, "Digital Advertising Market Study: Follow-up to Google/CMA meeting on 28 October 2019," GOOG-AT-MDL-006690096 at '111 (CI); Google internal document, "Bid DT Changes for 1st Price Auction," (July 25, 2019) GOOG-NE-07834872 at '874 (HCI).
[547] Google internal document, "Digital Advertising Market Study: Follow-up to Google/CMA meeting on 28 October 2019," GOOG-AT-MDL-006690096 at '111 (CI); [redacted].
[548] Google internal document, "Digital Advertising Market Study: Follow-up to Google/CMA meeting on 28 October 2019," GOOG-AT-MDL-006690096 at '111 (CI); [redacted]

1) The KeyPart field itself was "re-encoded" in the Bid Data Transfer files. This meant that for the same auction, the KeyPart in the Bid Data Transfer file was different than the KeyPart in other files, such as the Impression Data Transfer file. With no knowledge on how the KeyPart was re-encoded, publishers could not use this field to match the Bid Data Transfer files with other files.

2) Timestamps, including the TimeUsec2 field, were rounded such that they were recorded at the hour level, instead of at the microsecond level. Because the auction process occurs in seconds or even fractions of a second,[549] only having data at the hour level meant that publishers could no longer precisely match bids with an impression using timestamps.

215. Moreover, the BidPrice field of the winning bids would be rounded to increments of $0.10, while the BidAdvertiser, BidYieldGroupCompanyId, and BidYieldGroupNames fields were redacted entirely.[550]

216. This example with the Bid Data Transfer files shows that Google was able to limit information and transparency about its auctions to publishers.

217. To conclude, Exchange Bidding was Google's response to Header Bidding with a self-stated goal of resolving the technical challenges of Header Bidding. Unlike Header Bidding, which is usually implemented on the client-side, Exchange Bidding is a server-side solution, meaning that Google controls and mediates the process of interacting with bidders. As a result, exchange bidding resulted in in reduced visibility into the auction dynamics on the external server. Google states that Exchange Bidding demand sources and AdX demand sources compete equally in the unified auction on a net basis.

X. GOOGLE IMPLEMENTS PROJECT BERNANKE TO ADJUST GOOGLE ADS USERS' BIDS

A. Google released four iterations of Project Bernanke which adjusted Google's ad buying tool bids to win more auctions

218. Project Bernanke is an internal Google program within Google Ads designed to adjust advertiser bids to increase the numbers of auctions won by Google Ads in AdX and increase the

[549] See [redacted] Deposition, (April 3, 2024) at 169:20-171:20.
[550] [redacted]

revenue of Google Ads.[551] Project Bernanke was implemented in four phases – "Original Bernanke" in 2013, "Global Bernanke" in 2015, "Project Bell v2" in 2016 and "1P Bernanke" in 2019. Original Bernanke, Global Bernanke, and 1P Bernanke all maintained Bernanke pool(s) of money to subsidize bids in auctions where Google Ads bids would have lost, and recouped money through bid adjustments in auctions where bids from Google Ads bidders ranked on top.[552] Project Bernanke continued to operate in Google Ads as of the "June 2023" code snapshot (the most recent provided by Google).[553]

219. As previously stated, Google Ads has an internal buy-side auction, the CAT2 auction, that determines the highest Google Ads bids for submission into the AdX auction.[554] Within CAT2, the top one or two Google Ads bids, depending on the type of AdX auction, are selected[555] and submitted to compete in the AdX auction.[556] If a Google Ads bid wins the AdX auction, Google Ads takes a [redacted]%[557] revenue share from the payment made by the winning advertiser, which it extracts prior to the submission into the auction (*e.g.*, if the advertiser bid [redacted], the bid that went into the AdX auction would be for [redacted] to reflect a [redacted] revenue share for Google).[558]

220. At its launch, AdX operated as a modified second-price auction, meaning that the highest-bidding advertiser won the impression and paid the higher of either the reserve price or the

[551] [redacted] Google internal document, "Promo Packet," (September 5, 2019) GOOG-AT-MDL-B-002547429 at '430 (CI); [redacted] Deposition, (April 1, 2024) at 57:11-57:18; Google internal document, "Project Bernanke," (October 21, 2013) GOOG-AT-MDL-009831407 at '409 (CI); [redacted] Deposition, (April 3, 2024) at 195:22-197:8.

[552] Google internal document, "Native Formats Update," GOOG-NE-02635108 at '112 (HCI); Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '828 (HCI); Google internal document, "Alchemist: the Game of Arbitrage," GOOG-DOJ-AT-00568762 at '762 (HCI); [redacted] Deposition (April 26, 2024) at 94:2-8.

[553] See Appendix C Section B.19 for confirmation based on my analysis of Google's source code on Bernanke implementation in 2023.

[554] [redacted] Google internal document, "CAT2 First Price Auction," GOOG-AT-MDL-018531517 at '520 (HCI) [redacted]

[555] Prior to 2019, when AdX ran second-price auctions, CAT2 submitted up to two bids to AdX. In some cases, Google Ads could submit one or zero bids if it didn't have enough bids for a specific auction. Since AdX switched to a first-price model in 2019, CAT2 has been submitting only one bid.

[556] Google internal document, "Supermixer," (January 2020) GOOG-AT-MDL-001421306 at' 308 (HCI); Google internal document, "CAT2 First Price Auction," GOOG-AT-MDL-018531517 at '520 (HCI).

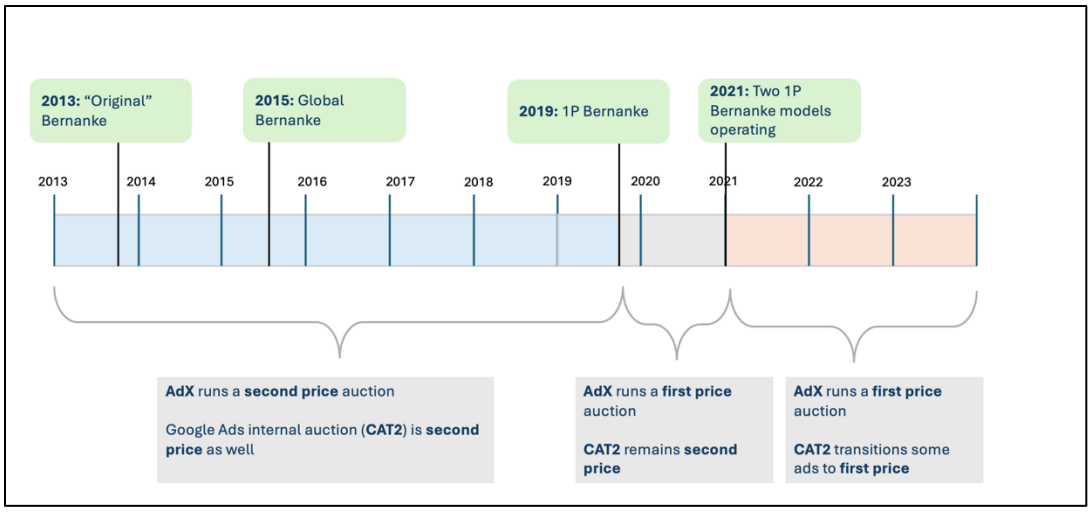
[557] Google Ads revenue share increased from [redacted] to [redacted] in the period between 2013 and 2016. Google internal document, "AdX Auction Optimizations," (May 10, 2016) GOOG-NE-06842715 at '730 (HCI).

[558] Google internal document, "Native Formats Update," GOOG-NE-02635108 at '112 (HCI); Google internal document, "Quality Revenue Optimizations Overview," (June, 2020) GOOG-DOJ-AT-01509153 at '153 (HCI).

amount of the second highest bid.[559] In 2019, AdX switched to a first-price model, where the highest-bidding advertiser above the reserve price wins and pays the exact amount they bid.[560] After the 2019 AdX first-price transition, Google Ads converted its second-price bids into equivalent first-price bids prior to submission into AdX.[561,562] CAT2 functioned as a modified second-price auction until it started transition to first-price style in 2021.[563] In 2021, Google Ads transitioned a portion of its ads to first-price bids, without conversion, while some remained second-price, depending on the bidding strategy.[564] A CAT2 first-price document from 2021 notes that CAT2 first-price supported fixed CPA[565] and target CPA bidding strategies.[566] All other ads, such as manual ads, would bid second-price values.[567] Figure 26 provides a timeline of all Project Bernanke changes, as well as the AdX and CAT2 auction types.

[559] Bigler, J., "Rolling out first price auctions to Google Ad Manager Partners," (September 5, 2019) https://blog.google/products/admanager/rolling-out-first-price-auctions-google-ad-manager-partners/. Accessed May 23, 2024; Google internal document, "AdX + gTrade Overview," (October 14, 2014) GOOG-DOJ-AT-00245254 at '261 (HCI).
[560] Bigler, J., "Rolling out first price auctions to Google Ad Manager Partners," (September 5, 2019) https://blog.google/products/admanager/rolling-out-first-price-auctions-google-ad-manager-partners/. Accessed May 23, 2024; Zaiceva, A., setupad, "First-Price vs. Second-Price Auction | Difference Explained," (April 22, 2021) https://setupad.com/blog/first-price-vs-second-price-auction/. Accessed May 23, 2024.
[561] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '829 (HCI).
[562] The bids for second-price auction are thus converted to bids for first-price auction based on bid shading, as bidders in first-price auction are not incentivized to bid their true value as in second-price auction. See Weinberg Report, para. 48.
[563] Google internal document, "Bidding Optimization for TaskAds & Survey," GOOG-DOJ-AT-02246549 at '553 (HCI).
[564] Google internal document, "CAT2 1P," (September 29, 2021) GOOG-AT-MDL-001132667 at '669 (HCI).
[565] CPA is "cost-per-action" where action is typically a purchase, registration, signup, etc.
[566] Google internal document, "CAT2 1P," (September 29, 2021) GOOG-AT-MDL-001132667 at '669 (HCI).
[567] UAC, GVP ads, video CTD ads, and Gmail front fill ads; Google internal document, "CAT2 First Price Auction," GOOG-AT-MDL-018531517 at '519 (HCI).

Figure 26: Timeline of Project Bernanke, AdX auction type, and CAT2 auction type



221. Google's implementation of Project Bernanke in 2013 leveraged two factors: (1) Google Ads submitted two bids into the AdX auction, and (2) Google Ads bids were often the two highest bids in the auction.[568] Google internally explained its two-bid strategy was meant to subsidize publishers, as Google Ads submitting two bids considerably increased publisher revenue.[569] For example, if Google Ads submitted a $1.00 and an $0.80 bid into an auction where the highest non-Google bid was $0.50, Google Ads won, and as a second-price auction, the advertiser paid $0.80. If Google Ads had only placed one bid, the advertiser would have paid $0.50. According to an internal Google analysis, if Google Ads stopped submitting two bids, publishers stood to lose [redacted] of their revenue.[570] Additionally, Google Ads reported that it won about [redacted] of all auctions in AdX and submitted the top two bids on approximately [redacted] of those auctions.[571] This meant that on approximately [redacted][572] of all auctions in AdX, Google already controlled advertiser cost and publisher payout. The large number of AdX auctions in which Google controlled the top bids and payouts gave Google the opportunity to adjust bids, advertiser costs, and publisher payouts through an undisclosed program called Project Bernanke.

[568] Google internal document, "gTrade Team Background," GOOG-NE-13624783 at '785 (HCI).
[569] Google internal document, "Aligning for a Programmatic Future," GOOG-NE-11902954 at '966 (HCI).
[570] Google internal document, "Project Bernanke and margins story," (2019) GOOG-AT-MDL-001412616 at '619 (CI).
[571] Google internal document, "gTrade Team Background," GOOG-NE-13624783 at '785 (HCI).
[572] 85% of 50%.

B. The original version of Project Bernanke adjusted bids while maintaining a fixed margin per publisher

222. The first version of Project Bernanke, "original Bernanke," was launched on November 11, 2013 on all AdX ad opportunities.[573] The program functioned by accumulating pools of money from some auctions and using that money to inflate bids in other auctions.[574] More specifically, in auctions where Google Ads bids were higher than the floor and other bids in the auction, Google Ads could decrease advertiser bids to secure ad impressions at a lower cost, while still charging the advertiser the higher price for the impression.[575] Conversely, when Google Ads bids were not high enough to win an auction, Bernanke could inflate advertiser bids to win the auction while only charging the advertisers the lower cost of their original bid.[576] Figure 27 and Figure 28 provides a visual of the scenario in which Bernanke was used to build a Bernanke pool on auctions where Google Ads placed the two highest bids and a scenario in which Bernanke was used to subsidize a bid Google Ads would have otherwise lost. A predictive algorithm determined whether to collect money or subsidize bids in each auction prior to submission into AdX.[577]

[573] [redacted] Deposition, (April 26, 2024) at 112:11-14; Google's First Am. Resps. and Objs. to Plaintiff's Third Set of Interrogs. (May 24, 2024) at 12.
[574] Google internal document, "gTrade Team Background," GOOG-NE-13624783 at '785 (HCI).
[575] Google internal document, "gTrade Team Background," GOOG-NE-13624783 at '785 (HCI); [redacted] Deposition, (April 26, 2024) at 319:21-320:5.
[576] Google internal document, "gTrade Team Background," GOOG-NE-13624783 at '785 (HCI).
[577] Google internal document, "Project Bernanke and margins story," (2019) GOOG-AT-MDL-001412616 at '622 (CI).

Figure 27: Bernanke was used to build the Bernanke pool in auctions where Google Ads places the two highest bids

[redacted]

Figure 28: Bernanke subsidized bids with money from the Bernanke pool in auctions Google would've otherwise lost

[redacted]

223. [redacted]

[redacted]

[578] Google internal document, "AdX + gTrade Overview" (October 14, 2014) GOOG-DOJ-AT-00245254 at '283 (HCI); [redacted] Deposition, (April 26, 2024) at 108:8-109:16.

224. In the context of Bernanke, the process of applying *alpha* and *beta* multipliers to live auction traffic is referred to as "online experiments."[583] The process of data collection and model training on past data is referred to as "offline experiments" in the context of Bernanke.[584] Bernanke's online and offline experiments are described in detail in Appendix C Section B.

225. The *alpha* and *beta* multipliers that are computed by the prediction model are used to adjust the top two Google Ads bids prior to submission into AdX – the highest Google Ads bid is multiplied by *alpha*, whereas the second-highest Google Ads bid is multiplied by *beta*.[585] In the first two versions of Project Bernanke – original Bernanke and Global Bernanke – *alpha* ranged between [redacted] meaning the highest bid could be inflated up to [redacted] its original value,

[579] Google internal document, "AdX + gTrade Overview," (October 14, 2014) GOOG-DOJ-AT-00245254 at '283 (HCI).
[580] See Appendix C Section B.3 for findings from my analysis of Google's source code on the configuration of Bernanke offline experiments.
[581] "Online experiments" in this context meaning situations in which exploratory values of Bernanke multipliers are applied to live auction traffic. See Appendix C Section B.22 for findings from my analysis of Google's source code on the configurations of Bernanke online experiments.
[582] [redacted]. See Google internal document, "Rethinking Bernanke: Grid search to line search," (October 30, 2014) GOOG-AT-MDL-008881638 at '638 (HCI).
[583] See Appendix C Section B.22 for findings from my analysis of Google's source code on the configurations of Bernanke online experiments.
[584] Google internal document, "Rethinking Bernanke: Grid search to line search," (October 30, 2014) GOOG-AT-MDL-008881638 at '638 (HCI); Google internal document, "Project Bernanke and margins story," (2019) GOOG-AT-MDL-001412616 at '622 (CI); see Appendix C Section B.3 for findings from my analysis of Google's source code on the configuration of Bernanke offline experiments.
[585] Google internal document, "Rethinking Bernanke: Grid search to line search," (October 30, 2014) GOOG-AT-MDL-008881638 at '638 (HCI); Google internal document, "Bernanke and Bell," GOOG-AT-MDL-018243919 at '921, '925 (HCI).

while *beta* ranged from [redacted], meaning the second-highest bid value was lowered anywhere from [redacted] of its original value.[586]

226. In the context of a second-price auction, which was how AdX functioned during the first two versions of Project Bernanke, the application of the *beta* multiplier on the second bid decreased the second highest bid, and consequently, the publisher payout.[587] In auctions where the predictive algorithm determined that Google Ads would have the two highest bids, the *beta* multiplier would decrease the second-highest bid; however, the advertiser would still be charged the original value of the second bid, prior to the application of the *beta* multiplier.[588] The difference between advertiser charge and publisher payout left Google Ads with a surplus of money. Google Ads retains its contractual [redacted] revenue share by subtracting from the surplus and placed the rest in a pool, which I refer to as the Bernanke pool.[589]

227. [redacted]

228. Figure 29 shows an example auction that demonstrates how Google built a pool using original Bernanke. Take an auction where Google Ads submits the two highest bids, $1.20 and

[586] Google internal document, "Bernanke and Bell," GOOG-AT-MDL-018243919 at '921, '925 (HCI); [redacted] Deposition, (April 26, 2024) at 109:18-21.
[587] Google internal document, GOOG-AT-MDL-016354537 at '540 (CI).
[588] Google internal document, GOOG-AT-MDL-016354537 at '540 (CI).
[589] Google internal document, GOOG-AT-MDL-016354537 at '540 (CI).
[590] Google internal document, GOOG-AT-MDL-016354537 at '540 (CI).
[591] Google internal document, GOOG-AT-MDL-016354537 at '540 (CI).
[592] Google internal document, GOOG-AT-MDL-016354537 at '542 (CI).
[593] See Appendix C Section B.20 for findings from my analysis of Google's on the implementation of Bernanke pool for bid adjustment.
[594] See Appendix C Section B.21 for findings from my analysis of Google's on the implementation of Bernanke pool for safety mechanism.

$1.00. Without Bernanke, the highest bid b_1 would win, and the advertiser would pay the amount of the second-highest bid, $1.00. Google Ads would keep [redacted] of what the advertiser paid, which is [redacted] in this example. The remaining [redacted] would be split across AdX's revenue share and the publisher's payout.

Figure 29: Example of an auction in which Google uses Bernanke to take a higher revenue share and build a Bernanke pool

	Bids	Auction Winner	Advertiser Charge	Publisher + AdX Payout	Google Ads Revenue + Bernanke Pool
Without Bernanke	(Google Ads) b_1 = $1.20 (Google Ads) b_2 = $1.00 (Non-GA) b_3 = $0.50	b_1	$1.00	[redacted]	
With Bernanke	**Bernanke multipliers:** $\alpha = 1$ $\beta = 0.1$ **Adjusted bids:** (Google Ads) $b_1 = 1.2 \cdot 1$ = $1.20 (Google Ads) $b_2 = 1.0 \cdot 0.1$ = $0.10 (Non – GA) b_3 = $0.50	b_1	$1.00	$0.50	$0.50

229. With Bernanke enabled and with *alpha* and *beta* multipliers equal to 1 and 0.1, respectively, Google Ads' second bid b_2 is multiplied by 0.1, reducing b_2 from $1.00 to $0.10 and making b_3, with a value of $0.50, the second-highest bid in the auction.[595] Consequently, Google Ads wins, pays the new second-highest value, $0.50, to the publisher but still charges the advertiser the original value of the second bid ($1.00). In summary, Google charges the advertiser $1.00, while paying the publisher (and the AdX revenue share) $0.50, leaving $0.50 or 50% for Google Ads' revenue share and the Bernanke pool.[596]

230. Figure 30 shows an example auction where original Bernanke helps a Google Ads advertiser to win an auction it would have otherwise lost. In this example, assume the auction provided is from the same publisher as in Figure 29, which means that Google has money in the Bernanke pool to spend (its revenue share for this publisher is currently 50%). The bid b_1 is $1.03 by a non-Google Ads bidder and is the highest value in the auction. Since Google Ads' highest bid

[595] The value of b_3 is either the original third-highest bid in the auction or the auction floor, whichever one is higher.
[596] This example is modeled after example provided in Google document, GOOG-AT-MDL-016354537 at '540 (CI).

is b_2 with a value of $0.80, Google would lose the auction without Bernanke. The Bernanke algorithm computes an *alpha* multiplier that raises Google's highest bid to $1.04, making it just high enough to be the new auction winner, while $1.03 becomes the second-highest bid. Consequently, Google charges the advertiser $0.80 and uses $0.23 from the Bernanke pool to subsidize the rest of the publisher and AdX payout. The advertiser is charged their bid as they would be in a first-price auction.

231. In summary, in the absence of Bernanke, Google Ads would have won one auction and made a total of [redacted] across the two examples.[597] With Bernanke enabled, Google Ads wins two auctions, the advertiser spent $1.80 and Google's revenue was [redacted] of the advertiser's spend.

Figure 30: Example of an auction in which Google uses Bernanke to win an auction it would have otherwise lost

	Bids	Auction Winner	Advertiser Charge	Publisher + AdX Payout	Google Ads Revenue + Bernanke Pool
Without Bernanke	(Non – GA) b_1 = $1.03 (Google Ads) b_2 = $0.80	b_1	NA (Not to Google)	NA (Not to Google)	$0.00 (didn't win)
With Bernanke	**Bernanke multipliers:** α = 1.3 β = 1 **Adjusted Bids:** (Non – GA) b_1 = $1.03 (Google Ads) b_2 = 0.80 · 1.3 = $1.04	b_2	$0.80	$1.03	$-0.23

C. Google uses a series of background experiments to calculate optimal values for Bernanke multipliers

232. In this section, I describe the experiments used to calculate the optimal Bernanke multipliers as observed in the "June 2023" Google code snapshot, although the implementation of these background experiments varied over time. As previously stated, the Bernanke *alpha* and *beta* multipliers are calculated from a series of offline experiments run on historical auction data, while online experiments specify which set of *alpha* and *beta* multipliers to be applied to what percentage of live auction traffic.[598]

[597] This example is modeled after example provided in Google internal document, GOOG-AT-MDL-016354537 at '540 (CI).
[598] Details about online and offline experiments are covered in Section X.C.

233. **Offline** experiments refer to the implementation of model training that occurs offline and are conducted independently of the auction occurring in real-time. Offline experiments use historical auction data to determine the optimal values of model parameters to be used in production, and typically consist of three parts:

A data pipeline to prepare training data.

2) A model pipeline to optimize model parameters.

3) Configuration hyperparameters to control the offline training process, including the frequency of training, and the input and output file paths.

234. [redacted]

[599] Google data production, samples of Google Ad Manager (GAM) log-level bid data produced on May 12, 2023.
[600] See Appendix C Section B.22 for findings from my analysis of Google's source code on the configurations of Bernanke online experiments.
[601] See Appendix C Section B.23 for findings from my analysis of Google's source code on Bernanke training data and data pipeline.
[602] See Appendix C Section B.23 for findings from my analysis of Google's source code on Bernanke training data and data pipeline.
[603] See Appendix C Section B.24 for findings from source code analysis on determination of optimal Bernanke multipliers.

[redacted][604,605,606]

235. [redacted].[607]

236. **Online** experiments refer to the configuration of parameters that are applied in live auctions, *i.e.*, the live auction execution loads parameter values specified in online experiment files. Online experiments typically consist of multiple sets of parameter values and serve to measure the impact of various parameter values on the auction outcome.[608]

237. Online experiments specify how Bernanke should be applied in the live auction, including the specific values of Bernanke parameters to be used, and the percentage of live traffic to apply the values on.[609] The values of Bernanke parameters, including Bernanke multipliers and pool-related fields (*e.g.*, pool id, and pool thresholds), are specified in two parts of a Bernanke online experiment file:

1) [redacted].[610]

2) [redacted]

[604] Google internal document, "Project Bernanke," (October 21, 2013) GOOG-AT-MDL-007393310 at '313 (CI).
[605] See Appendix C Section B.3 for findings from my analysis of Google's source code on the configuration of Bernanke offline experiments.
[606] See Appendix C Section B.23 for findings from my analysis of Google's source code on Bernanke training data and data pipeline.
[607] For specific values, see Appendix C Section B.25 for findings from my analysis of Google's source code on details about Bernanke SSTable.
[608] See Appendix C Section B.22 for findings from my analysis of Google's source code on the configurations of Bernanke online experiments.
[609] See Appendix C Section B.22 for findings from my analysis of Google's source code on the configurations of Bernanke online experiments.
[610] See Appendix C Section B.22 for findings from my analysis of Google's source code on the configurations of Bernanke online experiments.

[redacted].[611]

238. The percentage of auctions subject to Bernanke offline experiments and the mechanism of those experiments varied over time. For example, an internal Google document from 2013 states that the online experiments applied to [redacted] of auctions and raised the first bid four times its value, while lowering the second bid to zero.[612] A document from 2014, on the other hand, suggests that experiments tested various combinations of *alpha* and *beta* parameters, and the pair that maximized Google Ads profit was selected.[613] Google bids sub-optimally on auctions that are part of certain online experiments to gather data for Bernanke.[614]

239. To safeguard against extreme deviations from the target margin, Google implemented an online safety mechanism for Bernanke.[615] In this context, online means that the safety mechanism went into effect live, for each individual auction, after bid submission.[616,617] The safety mechanism calculated the expected margin for each publisher and would stop lowering the second bid if the expected margin exceeded [redacted] Similarly, it would stop increasing the first bid if the expected margin fell below [redacted].[618] In original Bernanke, the safety mechanism was maintained at per-publisher level. This meant that during the application of Bernanke bid adjustment, if the profit margin exceeded the target range for a given publisher, the safety mechanism would be triggered to override the values of *alpha* and *beta* multipliers with pre-defined values.[619]

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[611] See Appendix C Section B.22 for findings from my analysis of Google's source code on the configurations of Bernanke online experiments.
[612] Google internal document, "Project Bernanke," (October 21, 2013) GOOG-AT-MDL-007393310 at '312 (CI).
[613] Google internal document, "Rethinking Bernanke: Grid search to line search," (October 30, 2014) GOOG-AT-MDL-008881638 at '638 (HCI).
[614] Google internal document, "Smarter Exploration for Bernanke," (October 28, 2020) GOOG-DOJ-AT-02260412 at '412 (HCI).
[615] Google internal document, "Project Bernanke," (October 21, 2013) GOOG-AT-MDL-007393310 at '313 (CI).
[616] Google internal document, "Project Bernanke," (October 21, 2013) GOOG-AT-MDL-007393310 at '313 (CI); Google internal document, "1P Bernanke Pool Safety Mechanism Design Doc," (December 9, 2020) GOOG-AT-MDL-002307536 at '539 (HCI).
[617] See Appendix C Section B.21 for findings from my analysis of Google's on the implementation of Bernanke pool for safety mechanism.
[618] Google internal document, "Project Bernanke," (October 21, 2013) GOOG-AT-MDL-007393310 at '313 (CI).
[619] See Appendix C Section B.21 for findings from my analysis of Google's on the implementation of Bernanke pool for safety mechanism; [redacted] Deposition, (April 26, 2024) at 97:10-13.

240. Additionally, Google used a mechanism called "throttling" to disable Bernanke under certain conditions.[620,621] This mechanism controlled the maximum percentage of an advertiser's bids that could be raised via Bernanke.[622] According to internal Google documents, this was done to prevent advertisers from responding to Bernanke by reducing their bid and relying on Google to subsidize the necessary amount to win.[623] Google determined that the optimal throttling percentage per advertiser was [redacted] meaning that at most [redacted] of an advertiser's bids could be raised via Bernanke.[624]

241. A[redacted]

[620] Google internal document, "gTrade AdX Summit," (February 5, 2014) GOOG-NE-12949161 at '166, (CI).
[621] See Appendix C Section B.4 for findings from my analysis of Google's source code on Bernanke throttling.
[622] Google internal document, "gTrade AdX Summit," (February 5, 2014) GOOG-NE-12949161 at '166, (CI).
[623] Google internal document, "gTrade AdX Summit," (February 5, 2014) GOOG-NE-12949161 at '166, (CI).
[624] Google internal document, "gTrade AdX Summit," (February 5, 2014) GOOG-NE-12949161 at '167, (CI).
[625] Google internal document, "Protecting GDN/DBM Advertisers," (September 2016) GOOG-NE-10646295 at '299 (HCI).
[626] Google internal document, "Global Bernanke," (October 8, 2014) GOOG-AT-MDL-B-002122273 at '277 (HCI).
[627] See Appendix C B.26 for findings from my analysis of Google's source code on the determination of multi-call publishers.
[628] See Appendix C Section B.14 for findings from my analysis of Google's source code on the setup of mediation treatment in Bernanke workflow.
[629] See Appendix C Section B.15 for findings from my analysis of Google's source code on the implementation of turning off Bernanke for multi-call publishers.

D. Global Bernanke maintained a fixed margin across all publishers

242. Global Bernanke was launched in August of 2015 on all AdX ad opportunities and changed the per-publisher pool to a single pool shared among all publishers.[630,631] Instead of maintaining a pool for each publisher that could only be replenished or used to inflate bids on ad slots from that specific publisher, Google introduced a single pool for all publishers as a group.[632] This meant that the [redacted] revenue margin was now maintained on average across all publishers.[633] Google implemented a similar safety mechanism that prevented individual publisher revenue margin to Google Ads from dropping below [redacted] and publisher payout dropping below [redacted] of the revenue they would have received without Bernanke.[634] In other words, the mechanism aimed to prevent any publisher from losing more than [redacted] of their revenue due to Global Bernanke.[635]

243. Because the safety mechanism in the original Bernanke relied on the fact that Google should receive an average margin of [redacted] for each publisher, this mechanism was disabled when Global Bernanke was launched.[636] Around 2016, Google introduced a version of the safety mechanism for Global Bernanke that disabled Global Bernanke at a threshold, which was set based on publisher size and the estimated cost of the impression.[637]

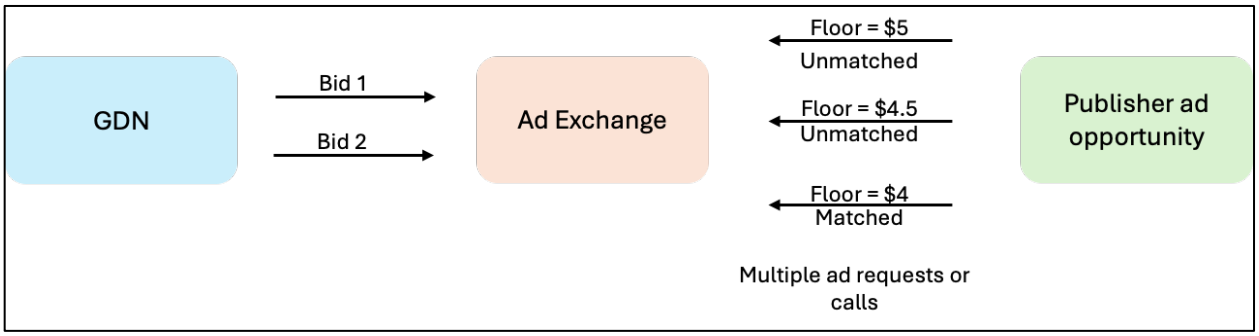
E. Google disabled Bernanke while bidding on multi-call publishers through Project Bell v2

244. In October 2016, Google updated Global Bernanke to include Project Bell v2 which included the detection and management of multiple calls from publishers.[638,639,640,641] Multi-

[630] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12
[631] Google internal email, (May 21, 2015) GOOG-DOJ-15637938 at '938 (HCI); Google internal document, "Global Bernanke," (July 26, 2015) GOOG-DOJ-AT-02471194 at '194 (HCI); [redacted] Deposition, (April 26, 2024) at 96:20-97:13, 112:18-22.
[632] Google internal email, (May 21, 2015) GOOG-DOJ-15637938 at '938 (HCI).
[633] Google internal document, "Global Bernanke," (July 26, 2015) GOOG-DOJ-AT-02471194 at '194 (HCI).
[634] Google internal document, "Global Bernanke," (July 26, 2015) GOOG-DOJ-AT-02471194 at '194 (HCI); [redacted] Deposition, (April 26, 2024) at 98:2-99:5.
[635] Google internal document, "Global Bernanke," (July 26, 2015) GOOG-DOJ-AT-02471194 at '194 (HCI).
[636] Google internal document, (March 6, 2016) GOOG-NE-13550381 at '381-382 (HCI).
[637] Google internal document, (March 6, 2016) GOOG-NE-13550381 at '383-387 (HCI).
[638] "Declaration of Nirmal Jayaram," (August 5, 2023) GOOG-AT-MDL-008842383 at '286; [redacted] Deposition, (April 26, 2024) at 104:19-24 (HCI).
[639] See Appendix C Section B.26 for findings from my analysis of Google's source code on the determination of multi-call publishers.
[640] See Appendix C Section B.14 for findings from my analysis of Google's source code on the setup of mediation treatment in Bernanke workflow.
[641] See Appendix C Section B.15 for findings from my analysis of Google's source code on the implementation of turning off Bernanke for multi-call publishers.

calling refers to when a publisher places multiple requests to an ad exchange for a single ad opportunity.[642] Multi-calling publishers can set different floors for each call they make to the ad exchange for the same impression.[643] For example, a multi-calling publisher can send a request to AdX with a price floor of $4.50 for a potential ad opportunity and a second request to AdX for the same ad opportunity with a price floor of $5. Figure 31 demonstrates how publishers send multiple calls on AdX.

Figure 31: Publishers sending multiple calls for a single ad opportunity



245. Prior to Project Bell, when AdX received multiple requests for the same ad opportunity, it would "process them as if these are three different ad calls and come up with three different bids."[644] While the requests are still processed separately, with the introduction of Project Bell v2 Google made three major changes when multi-calling was detected.[645] First, Google turned off Bernanke.[646] Next, Google applied a cap to the bid amount that would be submitted to the ad exchange, limiting how much the advertiser could bid.[647] Finally, Google prevented purchases on third-party exchanges when there was already a call for the same ad opportunity on AdX.[648]

F. Google adjusted the Bernanke algorithm to accommodate the switch to a first-price auction

246. In 2019, when AdX switched to a first-price auction, Google devised a version of Bernanke called "1P Bernanke" or "Alchemist" to mimic the functionality of second-price Bernanke in a first-

[642] [redacted] Deposition, (April 26, 2024) at 99:8-14.
[643] Google internal document, "Mediation: Double Calls Detection and Treatment," GOOG-AT-MDL-B-001602051 at '059 (CI).
[644] [redacted] Deposition, (April 26, 2024) at 100:10-18.
[645] [redacted] Deposition, (April 26, 2024) at 100:24-101:13; 105:2-8.
[646] Google internal document, "Mediation: Double Calls Detection and Treatment," GOOG-AT-MDL-B-001602051 at '066 (CI); [redacted] Deposition, (April 26, 2024) at 100:24-101:13; 105:2-8.
[647] [redacted] Deposition, (April 26, 2024) at 100:24-101:13; 105:2-8.
[648] [redacted] Deposition, (April 26, 2024) at 100:24-101:13; 105:2-8.

price auction.[649] 1P Bernanke launched in 2019 on all AdX ad opportunities.[650]

247.

[649] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '828 (HCI); Deposition, (April 26, 2024) at 107:2-6.
[650] Google's First Am. Resps. and Objs. to Plaintiff's Third Set of Interrogs. (May 24, 2024) at 12; Deposition, (April 26, 2024) at 112:23-113:9, 114:17-19.
[651] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '829 (HCI).
[652] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '829 (HCI).
[653] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '829 (HCI).
[654] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '829 (HCI).
[655] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '829 (HCI).
[656] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '829 (HCI).
[657] Google internal document, "The Alchemist's," GOOG-AT-MDL-013274837 at '843 (HCI).
[658] Google data production, samples of Google Ad Manager (GAM) log-level bid data produced on May 12, 2023.

[redacted].[660]

[redacted]

248. [redacted].

[659] See Appendix C Section B.29 for findings from source code analysis on the configuration of pHOB model pipeline.
[660] See Appendix C Section B.29 for findings from source code analysis on the configuration of pHOB model pipeline.
[661] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '829 (HCI).
[662] Google internal document, "The Alchemist," (March 2019) GOOG-DOJ-AT-02224828 at '829 (HCI); Google internal document, "Bidding Optimization for TaskAds and Survey," GOOG-AT-MDL-006692676 at '682 (CI).
[663] See Appendix C Section B.30 for findings from source code analysis on the formula of bid submitted to the AdX auction under 1P Bernanke.
[664] Google internal document, "Alchemist: the Game of Arbitrage," GOOG-DOJ-AT-00568762 at '762 (HCI).
[665] Google internal document, "Alchemist: the Game of Arbitrage," GOOG-DOJ-AT-00568762 at '762 - '763 (HCI).

[redacted]

[redacted]

249. [redacted]

[redacted]

[redacted]

666 Google internal document, "Bidding Optimization for TaskAds and Survey," GOOG-AT-MDL-006692676 at '682 -'683 (CI)
667 Based on Google internal document, "Hoover & Truthful Cost," (July 1, 2020) GOOG-AT-MDL-016353630 at '646 (CI), the formula for charging the advertisers may have been updated to max(f($v_1 \times a$) / a , $v_2 \times b$).
668 Google internal document, "The Alchemist's," GOOG-AT-MDL-013274837 at '841 (HCI).

[redacted].[670]

250. Figure 35 outlines the CAT2 serving process after AdX transitioned to a modified first-price auction, while CAT2 remained a modified second-price auction. The general purpose of this process is to charge the advertiser based on the second highest auction value, while submitting a first-price bid into the AdX auction; however, the process is very complex and involves several bid adjustments and sub auctions between different candidates. Since at this point CAT2 functions as a modified second-price auction, each winning bid has a value and a price because the winner does not necessary pay what they bid in a second-price auction.[671]

251. Ads designated as manual bidding and auto bidding participated in the same second-price auction.[672] Manual Google Ads bids are a bidding strategy in which advertisers set bids for individual targeting keywords or placements, while auto bidding ads are ads for which the publisher relinquishes bidding control to Google, for example a bidding strategy that maximizes clicks.[673] Both types of ads competed in a second-price auction within CAT2. Within CAT2 ads were grouped into subcategories and sub auctions were conducted within these groups. The second highest bid in each sub auction was used to determine the price of the winning bid. Sub auction results were compared based on the winning bid and the winner among the sub auctions was priced by the runner up sub auction winner.[674]

252. [redacted]

[669] Google internal document, "The Alchemist's," GOOG-AT-MDL-013274837 at '838 (HCI).
[670] Google internal email, GOOG-AT-MDL-001284725 at '725 – '728 (CI).
[671] Google internal document, "Cat2 1P Auction Infrastructure Design Doc," GOOG-DOJ-AT-00586479 at '484 (HCI). Describes how candidate bids are ranked and "priced" in the CAT2 auction. Candidates have a "bid" and a price because from the perspective of Google Ads advertisers, this is a modified second-price auction.
[672] Google internal document, "Cat2 1P Auction Infrastructure Design Doc," GOOG-DOJ-AT-00586479 at '479 (HCI).
[673] Google, "Manual CPC bidding," https://support.google.com/google-ads/answer/2390250. Accessed May 24, 2024.
[674] Google internal document, "Cat2 1P Auction Infrastructure Design Doc," GOOG-DOJ-AT-00586479 at '484 (HCI).

[redacted].[677]

[redacted]

253. As mentioned earlier, in 2021, CAT2 transitioned a portion of Google Ads bids to first-price.[679] This resulted in a complex bidding ecosystem in which both second-price and first-price ads competed in the CAT2 auction, and "2P" and "1P" Bernanke were applied to the respective

[675] Google internal document, "Cat2 1P Auction Infrastructure Design Doc," GOOG-DOJ-AT-00586479 at '488 (HCI).
[676] This includes programs such as revenue calibration, Hoover, Marple and eCPM capping which are outside the scope of this report.
[677] Google internal document, "Cat2 First Price Auction," GOOG-AT-MDL-018531517 at '520 (HCI).
[678] Google internal document, "Cat2 First Price Auction," GOOG-AT-MDL-018531517 at '520-'521 (HCI).
[679] Google document, "Bidding in Cat2 First Price Auction," GOOG-AT-MDL-000880955 at '956 (CI); See Appendix C Section B.16 for confirmation based on my analysis of Google's source code on the existence of 1P and 2P ads in CAT2 in 2023.

ads.[680] Despite being labeled as "2P" in Google internal documents, this version of Bernanke is not to be confused with earlier versions of Project Bernanke that were intended for bidding into a second-price AdX auction. While both are versions of first-price Bernanke, the algorithm is adjusted for the ad type that it serves and uses separate background experiments for each ad type. [redacted].[681]

254. A CAT2 first-price transition document from 2021 proposed migrating the fixed CPA[682] and target CPA bidding strategies, which are both auto bidding strategies, to first-price. All other ads, such as manual ads, would bid second-price values.[683] The overview of the ad serving process after 2021 is shown in Figure 36. Ads that are first-price are passed through the HDMI model, that serves as the auto-bidding model that determines the optimal bid in a first-price auction given the bidding strategy and the likelihood that the desired outcome (for example a click in a cost-per-click bidding type) will occur.[684] Next, the bids are passed through Bernanke for first-price bids, "1P Bernanke," before being submitted into the CAT2 first-price auction. Second-price or manual ads are passed through a separate Bernanke model for second-price ads, "2P Bernanke," and submitted into the CAT2 first-price auction along with the first-price bids.

255. According to the CAT2 first-price design document, the application of both types of Bernanke's translated first- and second-price bids into the same "units," meaning they can be compared in the CAT2 auction. The CAT2 auction was modified to be able to price both bid types. [redacted]".

256. DV360 PPO bids are also determined by the HDMI model and have first-price Bernanke applied and then compete in their own auction where the top bids are submitted into the mini

[680] Google document, "Bidding in Cat2 First Price Auction," GOOG-AT-MDL-000880955 at '965 (CI); See Appendix C Section B.19 for confirmation based on my analysis of Google's source code on Bernanke implementation in 2023.
[681] Google document, "Dynamic Backgrounds for Bernanke on Web," GOOG-AT-MDL-013211457 at'457 (HCI).
[682] CPA is "cost-per-action" where action is typically a purchase, registration, signup, etc.
[683] Google document, "CAT2 First Price Auction," GOOG-AT-MDL-018531517 at '519 (HCI).
[684] "HDMI (Hidden Density Model of Inventory) is a modelling and optimization engine used for auto-bidding. HDMI solves the optimization problem of any bidding strategy by finding the optimal [function] that maximizes the bidding strategy goal." Google internal document, "A brief overview of HDMI," GOOG-AT-MDL-004434946 at '946 (HCI); Google document, "CAT2 1P," (September 29, 2021) GOOG-AT-MDL-001132667 at '261 (HCI).

auction.[685] The mini auction compares PPO and CAT2 auction bids. In the mini auction, the selection of the winner amongst the PPO bids and Google Ads bids remains the same as before the CAT2 transition to first-price. However, the price bid update changed depending on whether the winning bid is first- or second-price. If the winning bid is first-price, the price of the bid remains unchanged, but if the bid is second-price, its value is adjusted based on the runner up bid and the Bernanke multipliers applied to both bids. The winning bid is adjusted by Google's bid adjustment algorithms and sent to the surplus maximizer function. The surplus maximizer function takes in the prediction of outside competition in AdX and uses that value to adjust the final winning bid prior to placement in AdX.[686]

257. Non-PPO bids in DV360 are submitted directly into the AdX auction after the top bid is selected and by-pass the serving flow used when CAT2 ran a second-price auction and after it transitioned to first-price.[687]

XI. GOOGLE IMPLEMENTS DYNAMIC REVENUE SHARE TO MODIFY THE ADX TAKE RATE

[685] Google document, "CAT2 1P," (September 29, 2021) GOOG-AT-MDL-001132667 at '681 (HCI).
[686] Google internal document, "CAT2 First Price Auction," GOOG-AT-MDL-018531517 at '521 (HCI). The surplus maximizer function takes in the "pHOB" which is the prediction of the highest-other-bid in the auction.
[687] Google internal document, "CAT2 First Price Auction," GOOG-AT-MDL-018531517 at '533 (HCI).
[688] Google internal document, "Bidding in Cat2 First Price Auction," GOOG-AT-MDL-000880955 at '965 (CI).

A. Google released three versions of the DRS program

258. Google released the "Dynamic Revenue Share" (DRS) feature within AdX on August 20, 2015 to increase the number of auctions in AdX that produced a winning bid.[689] Prior to DRS, AdX calculated a 20% take rate from the clearing price of each auction in AdX.[690] The remaining 80% of the bid must have been greater than the floor price for the bid to win the auction.[691]

259. As discussed in Section VII, sometimes AdX would lose its own auction because the highest AdX bid may not have cleared the EDA floor price; in these cases a guaranteed or remnant line item (depending on which was used to inform the floor price) would win the auction. Google's response was to design a program for AdX to clear the EDA floor price, even in situations where AdX would otherwise not have won the impression. This program reduced Google's take rate in some AdX auctions so that the highest bid, minus Google's reduced share, would clear the EDA floor price.[692] Google internally referred to this program as "Dynamic Revenue Share" (DRS). Google exempted their own buying platforms, Google Ads and DV360, from DRS v1 and v2, only applying these versions of DRS to non-Google buying tools[693] bidding in AdX.[694]

260. Google released three versions of DRS: DRS v1 on August 20, 2015, DRS v2 on December 1, 2016, and truthful DRS (tDRS) on July 17, 2018.[695] The first version of DRS lowered Google's take rate if doing so allowed a bid to win the auction as described above.[696] The second version of

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[689] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12; Google internal document, "Remove First Pricing in Sell-Side Dynamic Revenue Share," GOOG-NE-13204977 at '981 (HCI).

[690] Google internal document, "AdX dynamic sell-side revenue share (DRS v1) – project description /Mini PRD," GOOG-AT-MDL-009013303 at '303 (HCI); The 20% AdX revenue share percentage is not to be confused with the [redacted] taken by Google Ads. If a bid from Google Ads is placed into AdX, the [redacted] (can be less or more if Bernanke is operating on the bid) will be subtracted by Google Ads first. If this bid wins, the 20% will then be taken by AdX; While 20% was the default rate, some publishers negotiated lower rates. [redacted] Deposition, (April 19, 2024) at 214:8-19.

[691] Google internal document, "Remove First Pricing in Sell-Side Dynamic Revenue Share," GOOG-NE-13204977 at '978 (HCI)

[692] Google internal document, "AdX dynamic sell-side revenue share (DRS v1) – project description /Mini PRD," GOOG-AT-MDL-009013303 at '303 (HCI); [redacted] Deposition, (April 26, 2024) at 268:8-18; [redacted] Deposition, (April 17, 2024) at 138:1-17.

[693] Authorized buying tools place bids into AdX via the RTB protocol

[694] "One known issue with the current DRS is that it makes the auction untruthful as we determine the AdX revshare after seeing buyers' bids and use winner's bid to price itself (first-pricing) when the bid is within the dynamic region. This could incentivize buyers to bid strategically instead of truthfully to achieve better ROI and has been the key concern preventing AdWords and DBM from using DRS." Google internal document, "Truthful DRS Design Doc," GOOG-NE-13226622 at '622 (HCI).

[695] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.

[696] Google internal document, "Dynamic Sell-Side Revshare," (2015) GOOG-NE-13202025 at '031 (HCI); [redacted] Deposition, (April 17, 2024) at 138:1-21.

DRS raised and lowered the take rate to achieve an average of 20% across auctions.[697] tDRS mimicked the second version of DRS by using a machine learning model to predict the optimal take rate in a given auction without looking at auction bids in real-time.[698] Google shut off the DRS program pending redesign when AdX switched to a first-price auction in 2019.[699]

261. DRS was initially not disclosed to publishers, and publishers were opted into the program without their knowledge.[700] I understand that Google never implemented any way for publishers to opt out of DRS v1.[701]

B. The initial version of DRS (DRS v1) lowered AdX's take rate if doing so allowed the highest AdX bid to exceed the auction floor

262. The first version of DRS was launched in 2015 and only lowered AdX's revenue share, never raising it as in future versions of DRS. If a bid is above the floor, but the 20% AdX revenue share would cause it to fall below the floor, it was said to be in the "dynamic region" where DRS could be applied.[702] A Google internal document from 2016 indicates that [redacted] of all winning bids in the AdX auction were in the "dynamic region" (*i.e.*, these bids were near enough to the floor price that DRS could impact the auction outcome), and thus were eligible for DRS take rate adjustments.[703]

263. With DRS v1, Google was able to dynamically adjust its revenue share from anywhere from 0 to 20 percent.[704] However, I understand that Google believed that DRS created perverse incentives in advertisers and publishers. For example, if advertisers knew that Google was reducing Google's revenue share to win an auction, buyers would have an incentive to reduce their bids.[705] Similarly, if publishers knew that Google was reducing Google's revenue share in order to win auctions, publishers would have an incentive to increase their reserve prices.[706]

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[697] Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '241 (HCI).
[698] Google internal document, "Truthful DRS Design Doc," GOOG-NE-13226622 at '622 (HCI).
[699] Google internal document, "Dynamic Revenue Share," (May 13, 2016) GOOG-TEX-00858434 at '434 (HCI).
[700] Google internal document, "Dynamic Revenue Share," (May 13, 2016) GOOG-TEX-00858434 at '435-436 (HCI).
[701] [redacted] Deposition, (April 19, 2024) at 288:12-289:4.
[702] Google internal document, "Dynamic Sell-Side Revshare," (2015) GOOG-NE-13202025 at '032 (HCI).
[703] Google internal document, "Display Ads Research (Part II)," GOOG-AT-MDL-B-001628818 at '826 (CI).
[704] [redacted] Deposition, (April 19, 2024) at 232:25-233:9.
[705] Google document, "Dynamic Sell-Side Revshare," GOOG-NE-13202025 at '035-036 (HCI); Google document, "Dynamic Revenue Sharing: V1 and V2," GOOG-AT-MDL-001629019 at '027-038 (CI).
[706] Google document, "Dynamic Sell-Side Revshare," GOOG-NE-13202025 at '035-036 (HCI); Google document, "Dynamic Revenue Sharing: V1 and V2," GOOG-AT-MDL-001629019 at '027-038 (CI).

264. Google resolved these incentives by probabilistically throttling queries that were in the dynamic range.[707] Google calculated per-buyer and per-publisher AdX margins throughout the day.[708] For each incoming query, Google flipped a coin to determine whether it would throttle the publisher or the advertiser if the bids were in the dynamic range.[709] After flipping the coin, if Google's revenue share was less than 19%, Google applied a throttling probability to determine whether it would throttle the transaction, wherein the probability was determined by the following equation:[710]

[redacted]

265. [redacted]

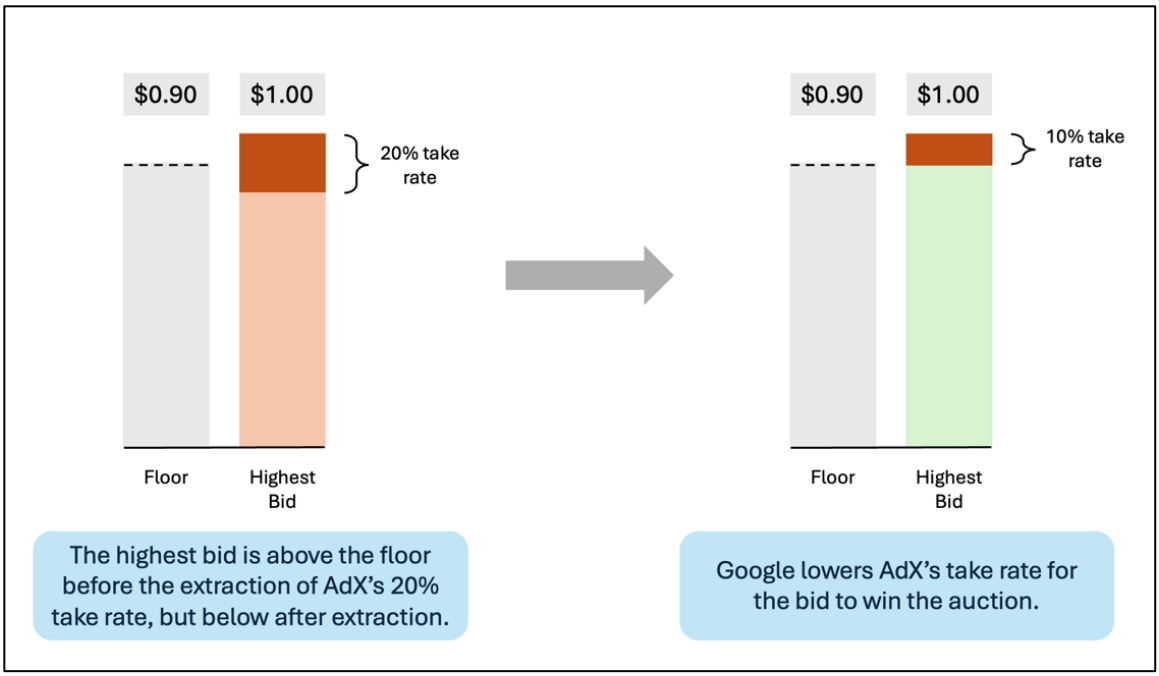
266. If Google determined that a query should be throttled, it did not transact the query.[712]

267. DRS v1 worked by lowering AdX's revenue share such that a bid that would otherwise not beat the floor price after accounting for a higher revenue share would now beat the floor with a lower revenue share applied. For example, as shown in Figure 37 if the highest bid in an auction with a $0.90 floor was $1.00, the bid could not win the auction since AdX took $0.20 as its revenue share, and the value of the bid was then $0.80. In this example, Google would use the

[707] Google document, "Dynamic Sell-Side Revshare," GOOG-NE-13202025 at '035-036 (HCI); Google document, "Dynamic Revenue Sharing: V1 and V2," GOOG-AT-MDL-001629019 at '027-038 (CI).
[708] Google document, "Dynamic Sell-Side Revshare," GOOG-NE-13202025 at '035-036 (HCI); Google document, "Dynamic Revenue Sharing: V1 and V2," GOOG-AT-MDL-001629019 at '027-038 (CI).
[709] Google document, "Dynamic Sell-Side Revshare," GOOG-NE-13202025 at '035-036 (HCI); Google document, "Dynamic Revenue Sharing: V1 and V2," GOOG-AT-MDL-001629019 at '027-038 (CI).
[710] Google document, "Dynamic Sell-Side Revshare," GOOG-NE-13202025 at '035-036 (HCI); Google document, "Dynamic Revenue Sharing: V1 and V2," GOOG-AT-MDL-001629019 at '027-038 (CI).
[711] Google document, "Dynamic Sell-Side Revshare," GOOG-NE-13202025 at '035-036 (HCI); Google document, "Dynamic Revenue Sharing: V1 and V2," GOOG-AT-MDL-001629019 at '027-038 (CI).
[712] Google document, "Dynamic Sell-Side Revshare," GOOG-NE-13202025 at '035-036 (HCI).

DRS v1 program to take a 10% revenue share from this bid instead of 20%, so the final bid value of $0.90 could exceed the floor price and win the auction.[713]

Figure 37: DRS v1 was used to lower the AdX take rate and cause a bid to win the auction[714]



268. If DRS v1 was applied to a bid, the advertiser was charged the original value of their bid.[715] As discussed in Sections B and A, AdX auctions were modified second-price prior to 2019, which meant that if the highest bid was above the floor after the deduction of Google's take rate, but the second highest bid was below the floor, the advertiser would be charged the value of the floor plus the take rate.[716] However, if DRS was applied to a bid, the advertiser always paid the value of their bid.[717] For example, in an auction with a $0.90 floor, if the highest advertiser bid was $1.00 and DRS was applied, the advertiser paid $1.00. However, if the advertiser had bid $1.50, enough to

[713] Google internal document, "AdX dynamic sell-side revenue share (DRS v1) – project description /Mini PRD," GOOG-AT-MDL-009013303 at '303 (HCI); Google internal document, "Display Ads Research (Part II)," GOOG-AT-MDL-B-001628818 at '833 (CI).
[714] Google internal document, "AdX dynamic sell-side revenue share (DRS v1) – project description /Mini PRD," GOOG-AT-MDL-009013303 at '303 (HCI); Google internal document, "Display Ads Research (Part II)," GOOG-AT-MDL-B-001628818 at '833 (CI).
[715] Google internal document, "Remove First Pricing in Sell-Side Dynamic Revshare," GOOG-NE-13204977 at '978 (HCI).
[716] Previously, when I discussed second- and first-price auction dynamics in Section III.B, all bids and the floor are assumed to be post-AdX take rate. In this section, we assume all bids and floor are pre-AdX take rate to explain the functionality of DRS.
[717] Google internal document, "Remove First Pricing in Sell-Side Dynamic Revshare," GOOG-NE-13204977 at '978 (HCI).

clear the floor without DRS, they would have paid the value of the floor, $0.90, plus the take rate, assuming that the second-highest bid in the auction is below the floor. DRS v1 determined how to adjust the revenue share after seeing the submitted bids.[718]

C. DRS v2 lowers and raises AdX's take rate to recoup lost revenue

269. DRS v2 was launched in December 2016 and allowed Google to raise the AdX take rate to counterbalance the auctions in which the take rate was lowered by DRS.[719] Since DRS v1 could only lower the AdX take rate, Google's average margin for AdX was reduced below 20%.[720] With DRS v2, if a winning bid was sufficiently above the floor, AdX would increase its revenue share above 20% to maintain a 20% revenue share on average for each publisher.[721] As with DRS v1, DRS v2 determined the AdX revenue share after seeing the bids.[722]

270. [redacted]

[718] [redacted] Deposition, (April 19, 2024) at 231:10-16.
[719] Google internal email, (May 28, 2016) GOOG-DOJ-14718539 at '539 (HCI); Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.
[720] Google internal email, (May 28, 2016) GOOG-DOJ-14718539 at '539 (HCI).; [redacted] Deposition, (April 19, 2024) at 235:6-236:5.
[721] Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
[722] [redacted] Deposition, (April 19, 2024) at 231:17-22.
[723] Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
[724] Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
[725] Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
[726] Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
[727] Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).

[redacted]

[redacted]

271. [redacted]

272. [redacted]

728 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
729 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
730 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
731 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
732 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
733 Google internal document, "Dynamic Revenue Sharing: V1 and V2," GOOG-AT-MDL-001629019 at 046-052 (CI).
734 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).

[redacted]

273. [redacted]

[redacted]

735 Google internal document, "Dynamic Revenue Sharing: V1 and V2," GOOG-AT-MDL-B-001629019 at '023 (CI).
736 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
737 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '245 (HCI).
738 This example assumes that this publisher is the same as in the previous example.
739 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
740 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
741 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).

[redacted]

274. [redacted]

[redacted] Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
743 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
744 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
745 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
746 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
747 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
748 Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).

[redacted]

D. Truthful DRS (tDRS) modified AdX's take rate based on a predictive model

275. tDRS was launched in July 2018 and used a machine learning model to predict the AdX revenue share that was necessary for the highest bid to clear the auction.[750] This version of DRS was implemented because the first two versions of DRS incentivized bidders to bid strategically, knowing that DRS was operating in AdX, instead of truthfully bidding what they were willing to pay.[751] Bids from Google's buyside products, Google Ads and DV360, were included in this version of DRS.[752] When tDRS was launched, DRS v2 was deactivated.[753]

276. [redacted]

[749] Google internal document, "AdX Dynamic Revshare v2: Launch Doc," GOOG-NE-13207241 at '246 (HCI).
[750] Google internal email, (September 29, 2017) GOOG-AT-MDL-B-003131145 at '145 (CI); Google internal document, "Truthful DRS Design Doc," GOOG-NE-13226622 at '622 (HCI); [redacted] Deposition, (April 19, 2024) at 290:9-20.; Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.
[751] Google internal document, "Truthful DRS Design Doc," GOOG-NE-13226622 at '622 (HCI).
[752] Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '131 (HCI).
[753] [redacted] Deposition, (April 19, 2024) at 334:14-22.

[redacted]

277. [redacted]

278. [redacted][2]

754 Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '129-130 (HCI).
755 Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '129-130 (HCI).
756 Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '129-130 (HCI).
757 Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '129-130 (HCI).
758 Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '129-130 (HCI).
759 Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '129-130 (HCI).
760 Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '129-130 (HCI).
761 Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '129-130 (HCI).
762 Based on the example in Google internal document, "Make AdX Dynamic Revshare Truthful," GOOG-DOJ-AT-02426129 at '129-130 (HCI).

[redacted]

279. [redacted]

280. I understand that tDRS was turned off in September 2019 when Google implemented a first-price auction on AdX.[767]

XII. GOOGLE IMPLEMENTS PROJECT POIROT TO REDUCE THE AMOUNT DV360 SPENDS ON SECOND-PRICE EXCHANGES WITH SOFT FLOORS

281. Project Poirot was launched on June 19, 2017, to reduce DV360's bids in second-price exchanges with "soft" floors.[768] Project Poirot was applied to every exchange.[769] As previously stated in Section B, auctions can be first or second-price. According to Google, some exchanges run a second-price auction where they allow bids below the floor to win the auction, resulting in a "soft" floor.[770] For example, an exchange may have a soft floor of $10 and a real floor of $8, which means that the floor sent in the bid request is $10; however, if a bid is above $8 it can still win the auction. Google uses Project Poirot to "detect and quantify deviations from second price-auctions" and has DV360 bid less in those exchanges. Advertisers may opt-out of Project Poirot in the DV360 interface.[771] As with Bernanke, Project Poirot took place after DV360 ran its auction, but before the bid was submitted to AdX.[772] Specifically, the Poirot experiment file was read and

[763] A logistic regression model is a statistical method to produce a binary outcome.
[764] Google internal document, "Truthful DRS Design Doc," GOOG-NE-13226622 at '623 (HCI).
[765] Google internal document, "Truthful DRS Design Doc," GOOG-NE-13226622 at '623 (HCI); [redacted] Deposition, (April 19, 2024) at 292:17-20.
[766] Google internal document, "Truthful DRS Design Doc," GOOG-NE-13226622 at '624 (HCI).
[767] [redacted] Deposition, (April 19, 2024) at 334:2-13, 335:4-24.
[768] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.; Google internal email, GOOG-NE-13558460 at '460 (HCI); Google introduced several updates to Project Poirot, the goal of this section is to describe the general purpose and function of the project.
[769] [redacted] Deposition, (April 26, 2024) at 246:22-247:2.
[770] Google internal document, "Bidding in adversarial auctions," GOOG-NE-05279363 at '373 (HCI).
[771] Google internal email, GOOG-NE-13558460 at '460 (HCI).
[772] [redacted] Deposition, (May 21, 2024) at 395:20-10.

applied as part of the bid adjustment in the bid computation as part of the auction preparation CAT2 Mixer.[773]

282. The amount that bids are lowered by Project Poirot is determined by a machine learning algorithm trained on DV360 data.[774] [redacted].[776] The multiplier is generated on a per-advertiser, per-exchange basis.[777] If the value of an impression is defined as the maximum of the floor and the second highest bid, then a perfect bidding algorithm in a clean second-price auction would bid the value for each impression.[778] In this case, the surplus would be zero, since the difference between the value and the cost is zero. Zero is the maximum surplus in a clean auction since the cost is always greater than or equal to the value. However, in a second-price auction with soft floors, bidding the value is not always optimal, since bidding below the floor can still result in winning an auction. In an auction with soft floors, the surplus can be positive since the value of an impression can be below the cost, *i.e.,* a publisher can win with a cost below the floor. The Poirot experiments consist of bids with different bid reduction multipliers, referred to as "*alpha*," the results of which are used in a model that maximizes surplus and determines the optimal bid reduction multiplier.[779] Initially, *alpha* was restricted to being between [redacted].[780] [redacted] Using this algorithm Google claims that exchanges such as OpenX and Pubmatic have second-price auctions with soft floors, while AdX, United, Adaptv and other exchanges run a clean second-price auction.[782]

[773] [redacted] Deposition, (May 21, 2024) at 441:13-21.
[774] Google internal document, "Project Poirot," (April 25, 2017) GOOG-DOJ-AT-02180605 at '607-609 (HCI); [redacted] Deposition, (May 21, 2024) at 431:12-17.
[775] [redacted] Deposition, (May 21, 2024) at 431:19-23.
[776] Google internal document, "Poirot Review," GOOG-DOJ-32261273 at '279 (CI); Google internal document, "Project Poirot," (April 25, 2017) GOOG-DOJ-AT-02180605 at '607 (HCI).
[777] [redacted] Deposition, (May 21, 2024) at 433:2-4.
[778] This abstracts away the fraction above the value that is necessary to win an auction.
[779] Google internal document, "Project Poirot," (April 25, 2017) GOOG-DOJ-AT-02180605 at '609 (HCI); [redacted] Deposition, (April 26, 2024) at 352:1-18; [redacted] Deposition, (May 21, 2024) at 379:12-17.
[780] [redacted] Deposition, (April 26, 2024) at 352:20-23.
[781] Google internal document, "Project Poirot," (April 25, 2017) GOOG-DOJ-AT-02180605 at '609 (HCI).
[782] Google internal document, "Poirot Review," GOOG-DOJ-32261273 at '280 and '282 (CI).

283. Following the initial version of Poirot, I understand that Google launched Poirot with Bid Buckets on January 8, 2018.[783] Advertisers would submit fixed CPM bids, known as "front-end bids."[784] Google would then take the front-end bids and group them into approximately [redacted] buckets of roughly even distribution consisting of bid ranges, running from small values to large values.[785] Each bucket then received a different multiplier.[786] [redacted].[787]

284. I understand that Google launched Poirot v2.0 on September 3, 2018.[788] Poirot v2.0 was also known as "Poirot with Auction Type Signal."[789] Poirot v2.0 changed the limits for *alpha* to be between [redacted].[790] Poirot v2.0 also introduced a signal to indicate an auction type signal, which was provided by exchanges to indicate whether an auction was a first-price or a second-price auction.[791] Poirot used the auction type signal to adjust the multiplier down based on the type of signal.[792] Where the auction was a true second-price auction, Poirot v2 did not adjust the multiplier.[793] Where the auction was indicated as a first-price auction, or where the auction was labelled as a second-price auction but wasn't entirely true, the multiplier was adjusted down.[794] Following Google's transition of AdX to a modified first-price auction, Poirot started reducing the bids that were submitted to AdX.[795]

285. Google launched another version of Poirot in September 2019 that incorporated minimum bid to win data provided by Google Ad Manager following Google's transition to a unified first-price auction.[796] By this point, Project Poirot was running on both DV360 and AdWords.[797]

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[783] [redacted] Deposition, (May 21, 2024) at 380:9-23; Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.
[784] [redacted] Deposition, (May 21, 2024) at 381:8-382:19.
[785] [redacted] Deposition, (May 21, 2024) at 382:20-383:16.
[786] [redacted] Deposition, (May 21, 2024) at 384:5-11.
[787] [redacted] Deposition, (May 21, 2024) at 384:13-19.
[788] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.
[789] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12
[790] [redacted] Deposition, (May 21, 2024) at 386:10-20.
[791] [redacted] Deposition, (May 21, 2024) at 386:10-387:2.
[792] [redacted] Deposition, (May 21, 2024) at 387:19-388:18.
[793] [redacted] Deposition, (May 21, 2024) at 387:19-388:18.
[794] [redacted] Deposition, (May 21, 2024) at 387:19-388:18.
[795] [redacted] Deposition, (May 21, 2024) at 398:14-18.
[796] [redacted] Deposition, (May 21, 2024) at 394:8-395:3; Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.
[797] [redacted] Deposition, (May 21, 2024) at 394:25-395.

286. I understand that Google provided a checkbox that permitted advertisers to opt out of Project Poirot, which said "[o]ptimize my fixed bidding to help me get the best possible price for each impression."[798] I further understand that the default was that Project Poirot was enabled, and that less than one percent of advertisers opted out.[799]

287. After rolling out Project Poirot, Google launched Project Marple.[800] Project Marple applied the Project Poirot methodology to Google Ads (formerly AdWords).[801] As with Poirot, Marple also uses the past seven days of data to train the model.[802] I understand that after the unified first-price migration, both AdWords (Marple) and DV360 (Poirot) used the minimum bid to win data.[803] As with Bernanke, Marple took place after AdWords ran its auction, but before the bids were submitted to AdX.[804] I understand that Project Poirot is still running today.[805]

XIII. GOOGLE IMPLEMENTED RESERVE PRICE OPTIMIZATION TO DYNAMICALLY INCREASE ADX FLOOR PRICES

288. Reserve Price Optimization (RPO), also known as "Dynamic Reserve Price Optimization," "AdX Dynamic Price" and publicly marketed as "Optimized Pricing" is an automated feature that dynamically increases auction floors to be as close to the anticipated highest bid as possible.[806]

289. Google released two types of RPO: second-price RPO, which was initially launched in March of 2015 and designed for second-price auctions, and first-price RPO (fRPO), which was launched in 2022 and designed to account for the changes accompanying AdX's transition to a first-price model.[807] I explain both in detail in the following subsections.

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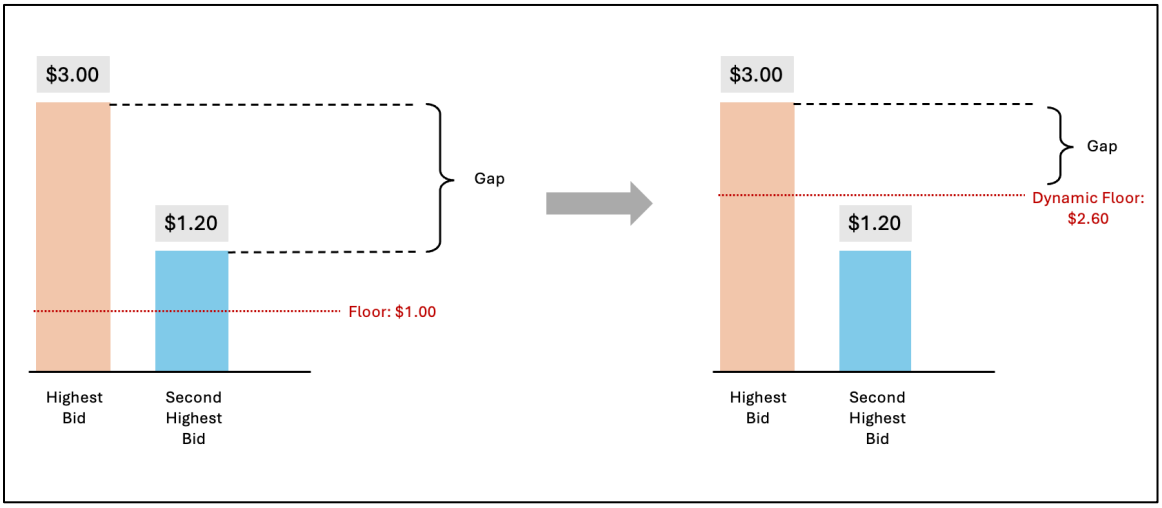
[798] [redacted] Deposition, (April 26, 2024) at 353:18-354:23.
[799] [redacted] Deposition, (April 26, 2024) at 249:9-250:21.
[800] [redacted] Deposition, (April 26, 2024) at 256:11-15.
[801] [redacted] Deposition, (April 26, 2024) at 255:17-256:25, 396:11-15.; [redacted] Deposition, (April 26, 2024) at 257:2-6.
[802] [redacted] Deposition, (May 21, 2024) at 431:25-432:5.
[803] [redacted] Deposition, (May 21, 2024) at 396:17-21.
[804] [redacted] Deposition, (May 21, 2024) at 395:20-10.
[805] [redacted] Deposition, (April 26, 2024) at 259:16-19.
[806] Google internal document, "2-Pager: RPO + OPR Commercialization," GOOG-AT-MDL-000989823 at '823-824 (HCI); [redacted] Deposition, (April 19, 2024) at 105:22-106:10.
[807] Google internal document, "This document lists launches where the responsible PM is maxl@, selected from Ariane with dates after Jan 2015, and launches from DRX IAS team selected since Jan 2016," GOOG-DOJ-15435288 at '289 (HCI); Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.

A. Second-price RPO raised auction floors on a per-buyer basis using historical AdX auction data

290. The initial version of second-price RPO was released March 31, 2015, and was designed specifically for AdX.[808] When AdX functioned as a second-price auction, Google observed that there was a sizable gap between the highest bid and what the advertiser actually paid (*i.e.*, the second highest bid).[809] Google therefore aimed to minimize the gap between the two values by setting the auction floor as close to the anticipated highest bid as possible. This is illustrated in Figure 40 below.

Figure 40: Second-price RPO



291. To achieve this, Google designed a model that analyzed historical AdX auction data to predict the highest possible bid from each buyer on a given segment of inventory.[810] Google then used these statistics to derive per-buyer auction floors that maximized publisher revenue.[811]

292. [redacted]

[808] Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '730 (HCI); Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.
[809] Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '732-733 (HCI).
[810] Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '734 (HCI).
[811] Google internal document, "AdX Per Buyer Reserve Prices," (October 2014) GOOG-AT-MDL-009012677 at '677 (HCI).

[redacted]

[redacted][818]

294. Google subsequently released several additional iterations of RPO. In October of 2015, Google released cookie-based RPO, where in addition to making predictions based on the inventory unit and the buyer, Google started incorporating cookie information.[819] According to Google, buyers often buy impressions based on cookies, rendering them important for the

[812] Google internal document, "AdX Per Buyer Reserve Prices," (October 2014) GOOG-AT-MDL-009012677 at '678 (HCI); Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '746 (HCI).
[813] Google internal document, "AdX Per Buyer Reserve Prices," (October 2014) GOOG-AT-MDL-009012677 at '677 (HCI); Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '746 (HCI).
[814] Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '746 (HCI).
[815] Google internal document, "AdX Per Buyer Reserve Prices," (October 2014) GOOG-AT-MDL-009012677 at '678-679 (HCI); Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '746 (HCI).
[816] Google internal document, "AdX Per Buyer Reserve Prices," (October 2014) GOOG-AT-MDL-009012677 at '680 (HCI); Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '746 (HCI).
[817] Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '741 (HCI).
[818] Google internal document, "AdX Per Buyer Reserve Prices," (October 2014) GOOG-AT-MDL-009012677 at '680 (HCI); Google internal document, "AdX Dynamic Price Models in MLT," (May 2015) GOOG-NE-13208126 at '127 (HCI).
[819] Google internal document, "Cookie based Dynamic Reserve Price Optimization (RPO) – mini PRD," GOOG-DOJ-AT-02320070 at '070 (HCI); Google internal document, "This document lists launches where the responsible PM is maxl@, selected from Ariane with dates after Jan 2015, and launches from DRX IAS team selected since Jan 2016," GOOG-DOJ-15435288 at '289 (HCI).

valuation of publisher inventory.[820] For example, someone located in Dallas, Texas who is interested in finance websites probably correlates to someone with higher net worth, therefore a more expensive brand may be interested in serving an ad. The more information you have the finer the targeting becomes.[821] As such, Google started incorporating cookies as an additional dimension into the pricing model such that a different reserve price was calculated and applied to each query based on the individual buying tool and the cookie. [redacted]

295. [redacted]er

[820] Google internal document, "Cookie based Dynamic Reserve Price Optimization (RPO) – mini PRD," GOOG-DOJ-AT-02320070 at '070 (HCI).
[821] Conversation with Professor Chandler, June 6, 2024.
[822] Google internal document, "Status: Code change Launched (cl/148248152). Experiment in serving with Biscotti Carveout at 1%," (May 2016) GOOG-NE-13217060 at '060 (HCI); Google internal document, "AdX Dynamic Price Models in MLT," (May 2015) GOOG-NE-13208126 at '127 (HCI).
[823] Google internal document, "Status: Code change Launched (cl/148248152). Experiment in serving with Biscotti Carveout at 1%," (May 2016) GOOG-NE-13217060 at '060 (HCI).
[824] Google internal document, "Dynamic Reserve Price Optimization Modeling Design," (January 2017) GOOG-AT-MDL-012683798 at '798 (CI). Note that according to other Google internal documents, this was subject to change. *See* Google internal document, "Optimized Pricing in the Open Auction Comms," (May 2016) GOOG-AT-MDL-001391101 at '108 (CI).
[825] Google internal document, "AdX Dynamic Price Models in MLT," (May 2015) GOOG-NE-13208126 at '127 (HCI).

[redacted]

296. [redacted]

[redacted]

297. [redacted]

826 Google internal document, "Status: Code change Launched (cl/148248152). Experiment in serving with Biscotti Carveout at 1%," (May 2016) GOOG-NE-13217060 at '061 (HCI); Google internal document, "Dynamic Reserve Price Optimization Modeling Design," (January 2017) GOOG-AT-MDL-012683798 at '799 (CI).
827 Google internal document, "Status: Code change Launched (cl/148248152). Experiment in serving with Biscotti Carveout at 1%," (May 2016) GOOG-NE-13217060 at '061 (HCI).
828 This example has been synthesized from an internal Google document. *See* Google internal document, "AdX Dynamic Price Models in MLT," (May 2015) GOOG-NE-13208126 at '127-128 (HCI).

[redacted]

298. [redacted]

299. [redacted]

[829] Google internal document, "Dynamic Reserve Price Optimization Modeling Design," (January 2017) GOOG-AT-MDL-012683798 at '799 (CI); Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '748 (HCI).
[830] Google internal document, "AdX Dynamic Price Models in MLT," (May 2015) GOOG-NE-13208126 at '131 (HCI).
[831] Google internal document, "go/rpo-exemption-policy-v2," (December 2017) GOOG-DOJ-28486313 at '313-314 (CI).
[832] Google internal document, "AdX Auction Optimizations," GOOG-NE-06842715 at '727 (HCI); Google internal document, "Optimized Pricing in the Open Auction Comms," (May 2016) GOOG-AT-MDL-001391101 at '104 (CI).
[833] Google internal document, "This document lists launches where the responsible PM is maxl@, selected from Ariane with dates after Jan 2015, and launches from DRX IAS team selected since Jan 2016," GOOG-DOJ-15435288 at '289 (CI).
[834] Google internal document, "AdX Dynamic Price: QEM Inventory Model Launch," (March 2016) GOOG-DOJ-AT-02421480 at '480 (HCI).
[835] Google internal document, "Optimized Pricing in the Open Auction Comms," (May 2016) GOOG-AT-MDL-001391101 at '109 (CI); Google internal document, "Ad Manager Ecosystem 101," GOOG-DOJ-AT-02199478 at '526 (HCI).
[836] Google internal document, "AdX Managed Reserves," GOOG-AT-MDL-019716988 at '988 (CI); Google internal document, "AdX Dynamic Price QEM Inventory Model," (March 2016) GOOG-AT-MDL-B-002862417 at '419 (CI).

300. [redacted]

B. First-price RPO raised auction floors uniformly across buyers based on historical AdX auction data

301. When AdX switched to a first-price auction, buyer behavior and therefore the technique for estimating floors changed. In a first-price auction, buyers are no longer incentivized to bid their true value and instead lower their bids to maximize utility. Further, winning buyers are incentivized to lower their bids over time in order to reduce the amount they have to pay to win. This is commonly referred to as bid shading.[840] The new version of RPO, first-price RPO (fRPO), therefore aimed to dynamically increase auction floors to prevent advertisers from lowering their bids.[841] Google identified rough criteria for a potential fRPO launch; namely fRPO must: treat every buyer equally, apply everywhere UPR applies, not decrease publisher revenue, increase RPI, and not hurt remnant revenue (especially from Header Bidding).[842]

302. [redacted]

[837] Google internal document, "go/rpo-exemption-policy-v2," (December 2017) GOOG-DOJ-28486313 at '313-'314 (CI); Google internal document, "Proposed way to simply describe the new auction dynamics (option 2 from go/jedi-auction-dynamics)," GOOG-TEX-00983966 at '966 (HCI).
[838] Google internal document, "Optimized Pricing in the Open Auction Comms," (May 2016) GOOG-AT-MDL-001391101 at '107 and '110 (CI).
[839] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.
[840] Weinberg Report, para. 48; [redacted] Deposition, (April 19, 2024) at 177:7-178:13.
[841] Google internal document, "Sellside Launch Doc: First-Price Reserve Price Optimization," GOOG-AT-MDL-001971579 at '579 (HCI); [redacted] Deposition, (April 19, 2024) at 111:7-21.
[842] Google internal document, "Discussion: RPO Path to Launch," GOOG-AT-MDL-001963256 at '256 (HCI).
[843] Google internal document, "Sellside Launch Doc: First-Price Reserve Price Optimization," GOOG-AT-MDL-001971579 at '581 (HCI).

[redacted]

303. [redacted]

[redacted]

[redacted]

844 Google internal document, "Sellside Launch Doc: First-Price Reserve Price Optimization," GOOG-AT-MDL-001971579 at '581 (HCI).
845 Google internal document, "Sellside Launch Doc: First-Price Reserve Price Optimization," GOOG-AT-MDL-001971579 at '581 (HCI).
846 Google internal document, "Sellside Launch Doc: First-Price Reserve Price Optimization," GOOG-AT-MDL-001971579 at '582 (HCI).
847 Google internal document, "Sellside Launch Doc: First-Price Reserve Price Optimization," GOOG-AT-MDL-001971579 at '586 (HCI).
848 Google internal document, "Estimating Buyer Reaction to Dynamic Reserve Prices," GOOG-AT-MDL-004016998 at '999 (HCI); [redacted] Deposition, (April 19, 2024) at 251:15-252:17.

[redacted]

305. First-price RPO was launched on limited traffic in June 2022.[851] Initially designed for Ad Manager's first-price auction on select web traffic, fRPO was extended to all web traffic in January 2023.[852] Unlike second-price RPO, first-price RPO is an optional feature and can be disabled in GAM network settings.[853]

XIV. UNIFIED PRICING RULES ENFORCE UNIFORM PRICE FLOORS ACROSS COMPETING EXCHANGES

306. Unified Pricing Rules (UPR), introduced by Google around May 2019 in an open beta,[854] is a feature within the GAM interface that enables publishers to set uniform pricing rules for a given segment of their inventory, which apply across all indirect demand sources, including AdX, Exchange Bidding participants and all remnant line items. UPR fully launched on September 25, 2019 and was contemporaneous with Google's transition to a unified first-price auction.[855]

A. Prior to UPR, publishers were able to set custom per-exchange floors and per-buyer tool floors

307. Prior to UPR, GAM ran a multistage auction where multiple exchanges competed with one another. Each exchange could have its own designated price floor, which was configured by the publisher through the exchange's interface.[856]

308. In addition to setting price floors on third-party exchanges, publishers using GAM could set price floors for each buying tool, advertiser, and other segments of inventory. Prior to UPR,

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[849] Google internal document, "Estimating Buyer Reaction to Dynamic Reserve Prices," GOOG-AT-MDL-004016998 at '999 (HCI).
[850] Google internal document, "Estimating Buyer Reaction to Dynamic Reserve Prices," GOOG-AT-MDL-004016998 at '004 (HCI).
[851] Google internal document, "1-Pager: RPO Launch Checklist," GOOG-AT-MDL-013262396 at '396 (HCI); Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12.
[852] Google internal workbook, "Launch ID 4125765 Details," GOOG-AT-MDL-009644380 (HCI); Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12; [redacted] Deposition, (April 19, 2024) at 279:10-21.
[853] Google Ad Manager Help, "Optimize pricing to reflect inventory's value," https://support.google.com/admanager/answer/12243638?hl=en. Accessed June 7, 2024.
[854] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12
[855] Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories, (May 24, 2024) at 12; Google internal document, "1st Price Migration," GOOG-DOJ-28243636 at '637 (CI).
[856] "Declaration of [redacted]," (August 4, 2023) GOOG-AT-MDL-008842393 at '405-406 (HCI); [redacted] Deposition, (May 24, 2024) at 658:17-660:11.

publishers could configure price floors for AdX through the "Open Auction Pricing Rules" interface within GAM. Each pricing rule specified a price floor for a particular portion of publisher inventory and could either be applied to all buyers or select advertisers, brands, and buying tools (including Google Ads, DV360, and Authorized Buyers).[857] There were three threshold types that publishers could choose from to set auction floors for a given segment of inventory:

1) **Fixed CPM.** With a fixed CPM, bids for the inventory were bound by a fixed floor set by the publisher.

Target CPM.[858] Target CPM specifies the minimum average CPM floor that a segment of inventory should meet averaged across multiple queries. In other words, it allows individual CPM floors on a given segment of inventory to vary (*i.e.*, be higher or lower than the target value) across several impressions if, on average, the floor is greater than or equal to the specified target value. For example, if a slice of inventory has a target CPM of $2.00, it may have floors of $1.50 and $2.50 for two separate impressions that fall under the pricing rule, for an average of $2.00. Google's target CPM model determines the optimal floor for the auction that maximizes publisher yield, while maintaining the target floor on average. Target CPM was available through Open Auction and DFP pricing rules prior to UPR.[859]

3) **Managed Reserves (MR).**[860] If a publisher enabled Managed Reserves on a given piece of inventory, it would override any floor configured by the publisher and was not bound by any constraints.[861] This feature was created to maximize overall publisher revenue and set new floors based on optimization calculations leveraging historical bid data.[862]

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[857] Incubeta DQ&A, "DQ&A Webinar: Google Ad Exchange Ad Manager 360 [Advanced]" (May 3, 2019) https://www.youtube.com/watch?v=UpXq66ME1gQ at 5:07; "Declaration of [redacted]," (August 4, 2023) GOOG-AT-MDL-008842393 at '405 (HCI); Google internal document, "1st Price Auction: Unified Pricing Rules," GOOG-AT-MDL-000993900 at '916 (CI).

[858] Google states that there is a small number of cases where they cannot match the target CPM, such as when the "rule is new and/or doesn't have enough data for full optimization" or when there is "significant fluctuation in the inventory traffic." Google Ad Manager Help, "Target CPM," https://support.google.com/admanager/answer/10357452?hl=en. Accessed June 7, 2024; See Appendix C Section B.31 for findings from my analysis of Google's source code on the training pipeline of Target CPM and Managed Reserves models.

[859] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-DOJ-AT-02134358 at '367 (HCI).

[860] See Appendix C Section B.31 for findings from my analysis of Google's source code on the training pipeline of Target CPM and Managed Reserves models.

[861] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-DOJ-AT-02134358 at '367 (HCI).

[862] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '510 (HCI).

309. Publishers could also assign a priority number for each rule in GAM, dictating which rule takes precedence in cases where two or more pricing rules overlap in inventory: the rule from the higher priority would apply to the available demand.[863] For third-party exchanges participating in Header Bidding and Exchange Bidding, publishers could similarly set custom floors through their Header Bidding setup or each third-party exchange's interface, respectively.[864]

310. Additionally, publishers had access to different "branding types," which controlled the amount of information about the webpage the user was visiting that was shared with buyers, to further customize their pricing rules. Prior to UPR, publishers could choose from three branding types: Branded, where the buyer would receive the full URL of the webpage being visited (*e.g.*, www.wsj.com/finance); Semi-Transparent, where the buyer would only receive the domain (*e.g.*, www.wsj.com); and Anonymous, where the buyer would receive no information.[865]

311. However, prior to UPR publishers could not use GAM to configure price floors for third-party exchanges bidding through Exchange Bidding, Header Bidding, or other channels.[866] Instead, as discussed above, publishers would set price floors for third-party exchanges through an interface provided by the exchange.

312. Once an impression became available on a publisher website:

1) If the publisher had a Header Bidding tag, the Header Bidding auction ran first. Winning bids were sent to DFP and generally matched to remnant line items, as described in Section VIII.

[863] Google internal document, "The Unified First Price Auction," (August 2019) GOOG-AT-MDL-000875073 at '083 (HCI).
[864] "[Prior to UPR] publishers had to undertake the complex and time-consuming task of configuring price floors separately on each exchange and network where their inventory was available." "Declaration of [redacted]," (August 4, 2023) GOOG-AT-MDL-008842393 at '405 (HCI). For Header Bidding wrappers such as Prebid.js, publishers could specify price floors at the ad unit level. Prebid, "Price Floors Module," https://docs.prebid.org/dev-docs/modules/floors.html. Accessed June 7, 2024. Each ad unit in Prebid would specify the demand partners that could bid for that ad unit, so when Prebid requested bids from these demand partners the floor price would be passed as well. Prebid, "Ad Unit Reference," https://docs.prebid.org/dev-docs/adunit-reference.html. Accessed May 23, 2024.
[865] Google internal document, "The Unified First Price Auction," (August 2019) GOOG-AT-MDL-000875073 at '083 (HCI); [redacted] Deposition, (May 24, 2024) at 652:24-654:10.
[866] "Declaration of [redacted]," (August 4, 2023) GOOG-AT-MDL-008842393 at '405 (HCI); [redacted] Deposition, (May 24, 2024) at 658:17-660:11.

2) GAM invoked one or more of the following features where applicable, which worked together to inform the price floor for AdX, and in some cases, for other indirect demand:[867]

i. As described in Section VII, GAM invoked **Enhanced Dynamic Allocation (EDA),** an automated feature enabled by default and not controlled by publishers, to calculate the best guaranteed line item based on line item priority and delivery schedule, and calculated a temporary CPM (tCPM) for it. In addition to tCPM, this value is often referred to as **EDA CPM, EDA price** or **Ad Manager Reserve Price**.[868]

ii. GAM then selected the remnant line item with the highest value CPM (vCPM), which informed the auction floor as well. The act of using the remnant line item with the highest vCPM to inform the auction floor was internally referred to as "**Last Look,"** as discussed in Section VII.B. In some internal documents, the maximum of tCPM calculated in the step above and vCPM calculated in this step was referred to as "third-party min CPM."[869]

iii. If the guaranteed line item selected by GAM in step (i) was a Standard line item and the publisher opted into **Optimized Competition (OC)**, a feature designed to lower excessively high EDA prices that are difficult to meet for even the highest bidders, DFP calculated the "OC floor." [870] [redacted]

[867] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-DOJ-AT-02134358 at '362 (HCI).
[868] Google internal document, "Reservation & Auction Dynamics," GOOG-AT-MDL-004291695 at '707 (CI); Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '493 (HCI); Google internal document, "Ad Manager Ecosystem 101," GOOG-DOJ-AT-02199478 at '505 (HCI).
[869] Google internal document, "go/rpo-exemption-policy," (December 2017) GOOG-DOJ-28486313 at '314 (CI).
[870] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '491, '493 (HCI); Google internal document, "Ad Manager Ecosystem 101," GOOG-DOJ-AT-02199478 at '522 (HCI).
[871] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '491, '493 (HCI).

[redacted]

iv. If the publisher opted into **DFP First Look (DFL),** which allowed to define custom price floors on distinct segments of inventory for select buyers, GAM incorporated the publisher-configured DFL floor into the final floor calculation.[873] DFL is intended to give buyers an ability to have a "first look" at publisher-selected impressions before other campaigns.[874] Note that DFL is only activated when the highest AdX bid is less than the EDA CPM, and if activated, takes precedence over both EDA and OC floors calculated in Steps (i) and (iii). [875] In other words, a first look bid can still win if it is below the EDA price.

v. GAM invoked second-price **Reserve Price Optimization** (**2P RPO**), also known as "Optimized Pricing" and "AdX Dynamic Price,"[876] which was a no opt-out feature that increased floors that Google considered were too low in comparison to what the buyers were willing to pay, as discussed in detail in Section XIII.A.[877] To reiterate, RPO could only increase the publisher-set auction floor and applied to AdX and AdSense publishers.[878]

3) Auction floors were set.

i. The per-buyer AdX floor prices were set to be the maximum of third-party CPM threshold, DFL, second-price RPO, publisher-configured AdX floor and a

[872] Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '491, '493 (HCI).
[873] By default, DFL is opted out of competing with Sponsorship guaranteed line items, though publishers can manually enable this option via network settings if they wish. Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '495 (HCI).
[874] Google internal document, "Ad Manager Ecosystem 101," GOOG-DOJ-AT-02199478 at '516 (HCI); [redacted] Deposition, (April 26, 2024) at 77:7-13.
[875] Google internal document, "Reservation & Auction Dynamics," GOOG-AT-MDL-004291695 at '700 (CI); Google internal document, "Yield Management in Google Ad Manager," (November 2018) GOOG-AT-MDL-000993483 at '495 (HCI).
[876] Google internal document, "Optimized Pricing in the Open Auction Comms," (May 2016) GOOG-AT-MDL-001391101 at '101 (CI).
[877] Google internal document, "Optimized Pricing in the Open Auction Comms," (May 2016) GOOG-AT-MDL-001391101 at '103, '107 (CI).
[878] Google internal document, "Reservation & Auction Dynamics," GOOG-AT-MDL-000993483 at '505 (HCI). As a reminder, buyers who were second pricing themselves in their bid requests were exempt from RPO. See Google internal document, "go/rpo-exemption-policy," (December 2017) GOOG-DOJ-28486313 at '314 (CI).

global minimum CPM equal to [redacted], which was used to ensure no impressions are served for free.[879]

ii. While Exchange Bidding participants were exempt from AdX Open Auction Pricing Rules, they were subject to the third-party CPM threshold and a global minimum CPM threshold enforced by GAM.[880] They could also each be bound by their own publisher-configured floors.

4) GAM called AdX to run an auction.

i. AdX targeting servers constructed bid requests storing the floor calculated in step 3.(i) and passed them to buyers.

ii. AdX performed auction filtering comparing the per-buyer floors to the bids received to decide the eligibility of the candidate to proceed in the auction process.[881]

iii. AdX ran a second-price auction among the surviving candidates and selected the winner. The AdX clearing price was calculated.[882]

5) The AdX clearing price was submitted to a "unified auction" to compete with Exchange Bidding buyers and remnant line items on a first-price basis.

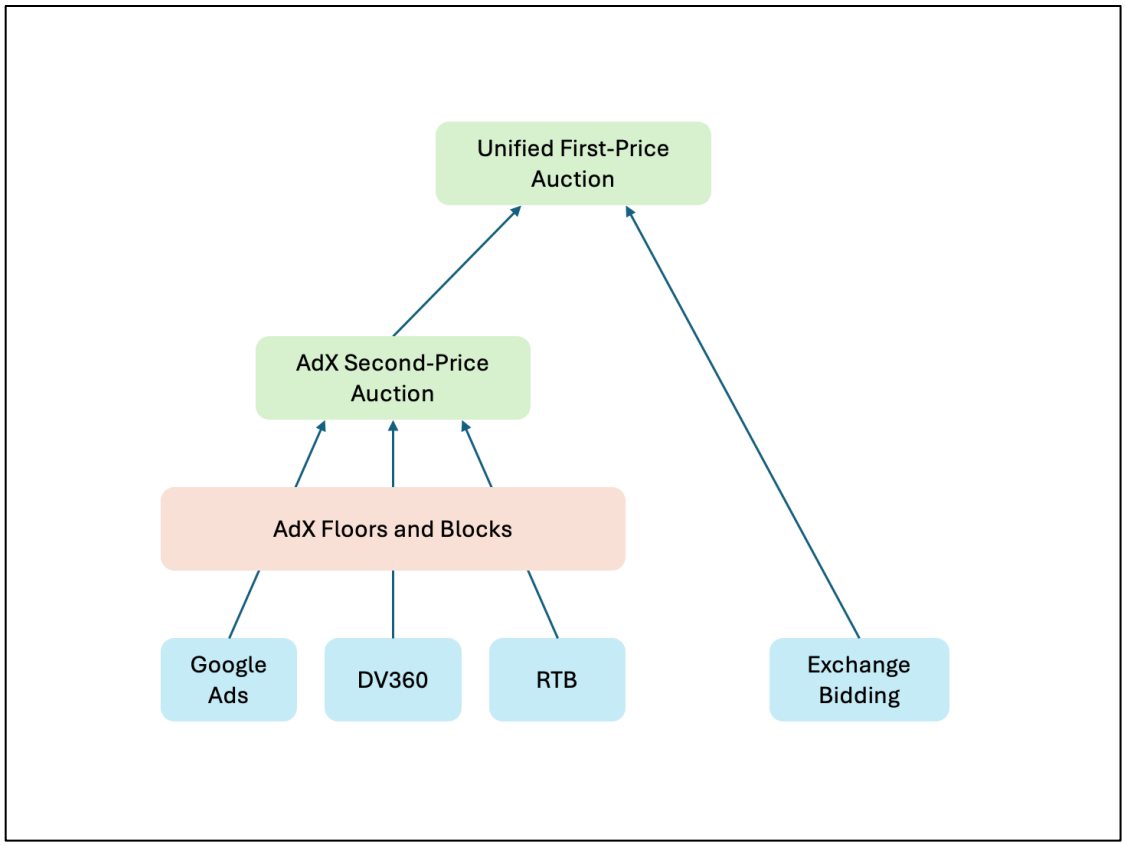
6) The highest bidder won the unified auction and the winning ad was served on the publisher website.

7) If no winner was selected, the ad slot was filled with a House ad.

313. Figure 42 below depicts the auction dynamics prior to UPR.

[879] Google internal document, "AdX Auction: Price Thresholds," (January 24, 2022) GOOG-AT-MDL-012693321 at '324 (HCI); Google internal document, "go/rpo-exemption-policy," (December 2017) GOOG-DOJ-28486313 at '314 (CI).
[880] Google internal document, "Jedi Auction, GA-style," GOOG-TEX-01280212 at '213 (CI); Google internal document, "1st Price Migration," GOOG-DOJ-28243636 at '640 (CI); Google internal document, "The Unified First Price Auction," (August 2019) GOOG-AT-MDL-000875073 at '083 (HCI).
[881] Google internal document, "AdX Dynamic Price," (August 2015) GOOG-NE-13204729 at '743 (HCI).
[882] Since AdX ran a second-price auction, the clearing price was equal to the maximum of the second highest bid and the price floor.

Figure 42: GAM auction dynamics prior to UPR[883]



B. Following the introduction of UPR, all indirect demand sources in GAM compete in a unified auction under a uniform price floor

314. With the launch of UPR, Google removed the intermediate second-price AdX auction, transitioning all indirect demand sources – AdX, Exchange Bidding participants and all remnant line items – to compete in a unified auction on a first-price basis, under a unified price floor. As such, the introduction of UPR was contemporaneous with the transition of AdX to a first-price auction. At the same time, as discussed in Section VII.B Google removed the Last Look advantage that AdX and Exchange Bidding participants had over remnant demand, which means that the highest vCPM among the non-guaranteed line items is no longer factored into the calculation of the auction floor.

315. As discussed above, prior to UPR publishers could set floors at the advertiser and buying tool levels GAM, and the third-party exchange level (through each third-party exchange's own platform). After UPR was launched, publishers could continue to set per-exchange floors through

[883] Google internal document, "AdX First Price Auction," GOOG-TEX-00841386 at '392 (HCI).

each exchange's platform and per-advertiser floors.[884] However, publishers were no longer able to set per-buyer floors; in other words, publishers could not set a floor for Google Ads, DV360, and third-party DSPs and ad networks.[885]

316. Similarly, publishers were now more limited in the branding types they could select and the amount of information they could share with buyers. After the launch of UPR, publishers could still select the Branded and Semi-Transparent branding types, but the Anonymous branding type was removed.[886] This meant that publishers no longer had the option to send no information about the webpage visited by the user to buyers.

317. To facilitate UPR configurations, Google launched a central user interface enabling publishers to set price floors across indirect demand. Publishers are limited to 200 pricing rules per GAM account.[887] Each UPR specifies an auction floor for a given segment of inventory using either a fixed CPM, an average or target CPM or the "optimized floor" feature, which completely relinquishes control of floors to Google's models.[888] While the majority of pricing rules specify a single price floor, the targeting for floor prices can overlap across multiple rules and publishers can set multiple floor prices for each unified pricing rule.[889] Publishers can create custom floors for certain advertisers, brands, sizes and creative types; these custom floors apply to AdX and Exchange Bidding demand only.[890] When a bid request is made for a given segment of inventory, GAM retrieves the pricing rule(s) that target the specific request using selectors specified in the

[884] "Declaration of [redacted]," (August 4, 2023) GOOG-AT-MDL-008842393 at '405-'406 (HCI); Google, "Unified pricing rules," https://support.google.com/admanager/answer/9298008. Accessed May 23, 2024.
[885] "Declaration of [redacted]," (August 4, 2023) GOOG-AT-MDL-008842393 at '406 (HCI); Google internal document, "The Unified First Price Auction," (August 2019) GOOG-AT-MDL-000875073 at '083 (HCI).
[886] Google internal document, "The Unified First Price Auction," (August 2019) GOOG-AT-MDL-000875073 at '083 (HCI); [redacted] Deposition, (May 24, 2024) at 652:24-654:10.
[887] "Unified pricing rules," Google Ad Manager Help, https://support.google.com/admanager/answer/9298008. Accessed May 23, 2024.
[888] Target cost-per-thousand impressions is the bid set based on the average amount advertisers are willing to pay every thousand times their ad is shown. Google Ads, "Target cost-per-thousand impressions (tCPM)," https://support.google.com/google-ads/answer/9158634. Accessed May 24, 2024; "Optimized floors" is internally referred to as "optimized pricing rules" at Google and is not to be confused with RPO, described in Section XIII, which is marketed as "optimized pricing." "Optimized floors" is a feature that sets revenue-maximizing floors based using models that account for bidder behavior. *See* Google internal document, "2-Pager: RPO + OPR Commercialization," GOOG-AT-MDL-000989823 at '823-824 (HCI).
[889] Google internal document, "PRD: Bid Insights – Auction Simulator," (January 24, 2020) GOOG-DOJ-AT-02200940 at '941 (HCI).
[890] Google internal document, "1st Price Auction Unified Pricing Rules," GOOG-AT-MDL-000993900 at '914 (CI). Floor prices for a specific advertiser, brand, size, or other item are not included in the floor price sent to buyers. Google, "Unified pricing rules," https://support.google.com/admanager/answer/9298008. Accessed May 23, 2024.

rule, such as candidate matching and targeting.[891] If the request matches more than one rule, the rule with the highest fixed CPM or publisher-entered target CPM applies.[892] Conversely, if no rules match the targeting, the UPR floor defaults to $0.[893]

318. Once an impression becomes available on a publisher website:

1) If the publisher has a Header Bidding tag, the Header Bidding auction runs first. The floors here are not bound by UPR as the auction takes place outside of DFP.

2) Header Bidding bids are passed into DFP as remnant line items.

3) GAM determines which UPR rule(s) apply to the inventory and selects the maximum floor of all rules that apply.

4) GAM invokes Enhanced Dynamic Allocation. Temporary CPM (tCPM) is calculated for eligible guaranteed line items.

5) GAM invokes the same floor "optimization" features described in the pre-UPR process, except that second-price RPO is overridden by first-price RPO, as explained in Section XIII. Note that post-UPR, these features apply across all indirect demand. For example, the target CPM, which previously only applied to AdX and Exchange Bidding buyers, now extends to remnant line items with value CPMs, and can be enabled or disabled by the publisher on a per-rule basis.[894]

[891] Google internal document, "AdX Auction: Price Thresholds," (January 24, 2022) GOOG-AT-MDL-012693321 at '325 (HCI).
[892] If only fixed CPM rules apply to a given piece of inventory, the one with the highest value will be the final floor. If only rules with tCPMs apply to the inventory, the one with the highest target value will be applied; however, the final floor may be lower than the target if Google's target CPM model determines that this is the optimal floor for the inventory. If a mix of fixed and target CPM rules apply to the inventory, the one with the highest fixed or target value will be selected; however, if a target CPM rule is selected, the value of the final floor determined by the tCPM model cannot be lower than any fixed CPM that applies. In conclusion, if only fixed CPM rules apply to an auction, the floor value of that auction will never be lower than any of the values specified in those rules. Google internal document, "Optimized Pricing Rules Design Doc," GOOG-AT-MDL-001403170 at '171 (HCI); Google internal document, "AdX Auction: Price Thresholds," (January 24, 2022) GOOG-AT-MDL-012693321 at '325 (HCI).
[893] Google internal document, "1st Price Auction Unified Pricing Rules," GOOG-AT-MDL-000993900 at '919 (CI).
[894] Google internal document, "1st Price Auction Unified Pricing Rules," GOOG-AT-MDL-000993900 at '922 (CI).

6) The Unified Auction floor is determined according to the below formula.[895]

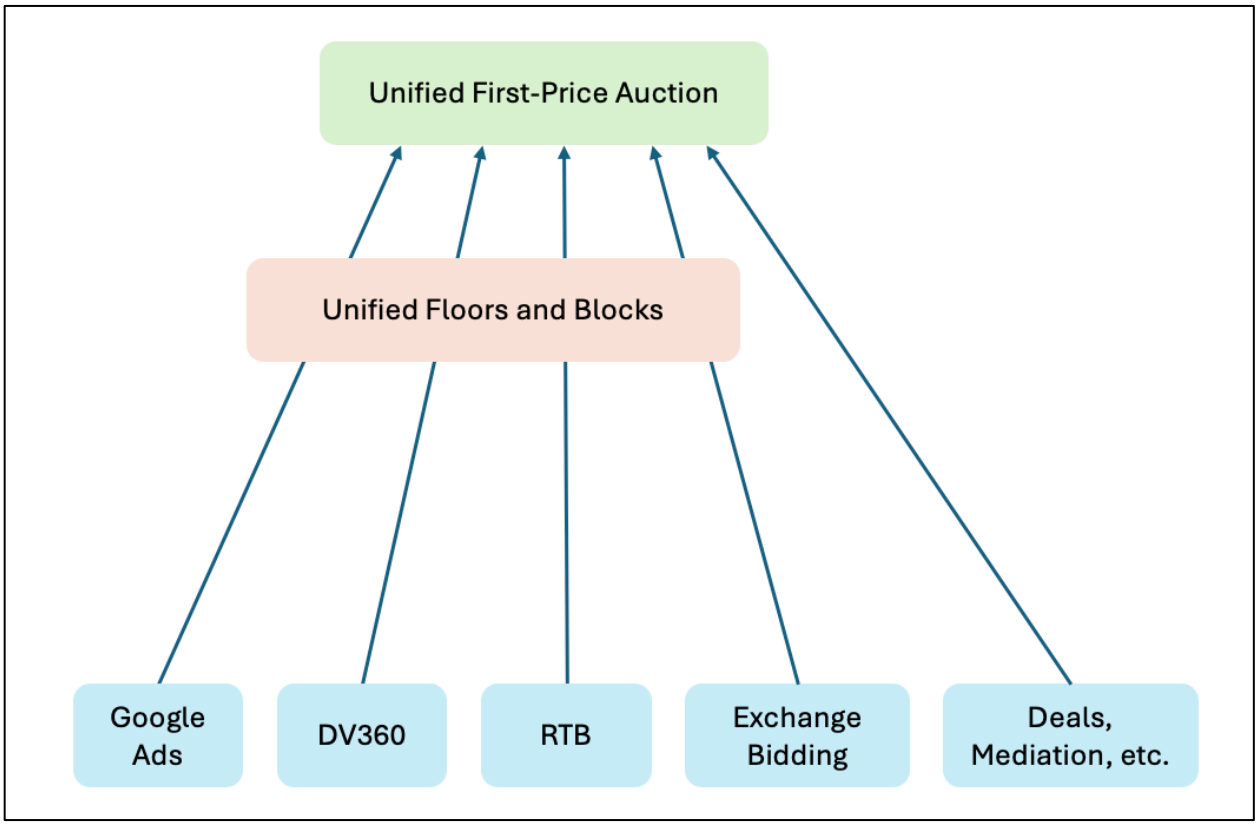
[redacted]

7) Buying All indirect demand sources, including AdX, Exchange Bidding, remnant line items (including Header Bidding line items) and guaranteed line items compete under the same floor in a unified auction. Google selects the candidate with the highest bid that beats the floor price as the winner.

8) If no winner is selected, a House line item gets served. Note that UPR does not apply to House line items, so they are not bound by the Unified Pricing Rules.[896]

319. Figure 43 shows the auction dynamics after the launch of UPR.

Figure 43: GAM auction dynamics after UPR launch[897]



[895] Google internal document, "Product Strategy for Auction Floors," (July 13, 2020) GOOG-AT-MDL-006197129 at '129 (CI); See Appendix C Section B.32 for findings from my analysis of Google's source code on the different CPM thresholds for floor sharing and auction candidate filtering.
[896] Google Ad Manager Help, "Unified pricing rules," https://support.google.com/admanager/answer/9298008. Accessed May 23, 2024.
[897] Google internal document, "AdX First Price Auction," GOOG-TEX-00841386 at '393 (HCI).

C. House Line Items allowed for circumvention of UPR

320. House line items are the lowest priority line items and are served when an ad cannot otherwise be filled. They usually contain advertisements for the publisher's own product (for example, an ad calling users to subscribe for the New York Times on the New York Times website).[898] Publishers have an option to set a CPM in order to establish an order of priority for House ads to serve.[899] For example, if a publisher only has one $2.00 floor rule for all of their inventory, and an impression becomes available that neither guaranteed nor remnant demand can fill, a House line item with a CPM of $1.00 can still be served as a fallback option. If there were two house line items with CPMs of $1.00 and $0, the ad with the $1.00 "bid" would be displayed.

321. Because House line items do not fall under Unified Pricing Rules, publishers discovered a way to utilize them to circumvent the program.[900] The strategy entailed setting high price floors through the Unified Pricing Rules, while sending their Header Bidding Price Priority line items to House line items instead.[901] As line items covered by UPR (*e.g.,* Price Priority, Bulk, Network line items and AdX) are served before House line items, publisher inventory was first offered at a high price for remnant demand, including AdX. If the inventory did not sell at that high price, it would be sold via House line items at lower prices through Header Bidding third-party exchanges, similarly to the way auctions were often structured prior to UPR.

322. In response to publishers circumventing UPR, Google updated its line item use policy to deem any use of House line items for ads that are not for the publisher's own product as "invalid activity."[902] [redacted] was one of the publishers Google noticed utilizing House line items to circumvent UPR.[903] A communication document set to be publicly announced in January 2020, states that "house line items may only be used for representing demand where you, the Ad Manager account, own the product or service being advertised," and that "you may only use line items for the specific purposes described below and any other use will be treated as invalid

[898] Google Ad Manager Help, "System maximums and limits," https://support.google.com/admanager/answer/1628457. Accessed May 24, 2024.
[899] Google Ad Manager Help, "House line items," https://support.google.com/admanager/answer/79305?hl=en. Accessed May 23, 2024.
[900] Google internal document, "AccuWeather notes," (November 13, 2019) GOOG-TEX-00857298 at '298 (HCI).
[901] Google internal email, (September 26, 2019) GOOG-DOJ-AT-00175537 at '537 (HCI).
[902] Google internal document, "DotDash Ad Manager Line Item policy change," (January 21, 2020) GOOG-DOJ-AT-02169562 at '563 (HCI).
[903] Google internal email, (September 26, 2019) GOOG-DOJ-AT-00175537 at '537 (HCI).

activity."[904] Google gave [redacted] 90 days to adjust their line items berna the new policy went into effect.[905] [redacted] reaction was that this policy change "was a big deal and [[redacted] had] put in work/time to get in a stable place where they are now. Google [is] forcing a disruption in their business & requiring a lot of work from their end to readjust strategy."[906] As of 2024, the same policy applies to GAM House line items.[907]

* * *

323. While the systems laid out above are separated by section, it is my opinion that the implementation or use of any individual system did not foreclose the use of a separate system for any particular auction. I understand that, to the extent the system existed at that time, any individual auction could have any, all, or any combination of the above systems run.

[904] Google internal document, "[redacted] Ad Manager Line Item policy change," (January 21, 2020) GOOG-DOJ-AT-02169562 at '563 (HCI).
[905] Google internal document, "[redacted] Ad Manager Line Item policy change," (January 21, 2020) GOOG-DOJ-AT-02169562 at '565 (HCI).
[906] Google internal document, "[redacted] Ad Manager Line Item policy change," (January 21, 2020) GOOG-DOJ-AT-02169562 at '564 (HCI).
[907] Google Ad Manager Help, "System maximums and limits," https://support.google.com/admanager/answer/1628457. Accessed May 24, 2024.

XV. APPENDIX A: MATERIALS RELIED UPON

A. Declarations, Depositions and ROG responses

Declaration of [redacted] (August 4, 2023) and exhibits

Deposition of [redacted] (April 23, 2024) and exhibits

Deposition of [redacted] (April 1, 2024) and exhibits

Deposition of [redacted] (April 19, 2024) and exhibits

Deposition of [redacted] (April 26, 2024) and exhibits

Deposition of [redacted] (May 23, 2024) and exhibits

Deposition of [redacted] (April 17, 2024) and exhibits

Deposition of [redacted] (April 24, 2024) and exhibits

Deposition of [redacted] (April 19, 2024) and exhibits

Deposition of [redacted] (April 3, 2024) and exhibits

Deposition of [redacted] (April 12, 2024) and exhibits

Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories (May 24, 2024)

B. Documents from Production

GOOG-AT-MDL-000009165
GOOG-AT-MDL-000875073
GOOG-AT-MDL-000880955
GOOG-AT-MDL-000989823
GOOG-AT-MDL-000993446
GOOG-AT-MDL-000993483
GOOG-AT-MDL-000993900
GOOG-AT-MDL-001004706
GOOG-AT-MDL-001110980
GOOG-AT-MDL-001132667
GOOG-AT-MDL-001284725
GOOG-AT-MDL-001391101
GOOG-AT-MDL-001403170
GOOG-AT-MDL-001409774
GOOG-AT-MDL-001412616
GOOG-AT-MDL-001418741
GOOG-AT-MDL-001418931
GOOG-AT-MDL-001421306
GOOG-AT-MDL-001793318
GOOG-AT-MDL-001963256
GOOG-AT-MDL-001963813
GOOG-AT-MDL-001971579
GOOG-AT-MDL-002011973
GOOG-AT-MDL-002295716
GOOG-AT-MDL-002307536
GOOG-AT-MDL-003109989
GOOG-AT-MDL-003565982
GOOG-AT-MDL-003991554

GOOG-AT-MDL-004016998
GOOG-AT-MDL-004122442
GOOG-AT-MDL-004221745
GOOG-AT-MDL-004284449
GOOG-AT-MDL-004288612
GOOG-AT-MDL-004291695
GOOG-AT-MDL-004300268
GOOG-AT-MDL-004434946
GOOG-AT-MDL-004544150
GOOG-AT-MDL-006138947
GOOG-AT-MDL-006197129
GOOG-AT-MDL-006690096
GOOG-AT-MDL-006692676
GOOG-AT-MDL-007275806
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GOOG-AT-MDL-007418936
GOOG-AT-MDL-008236563
GOOG-AT-MDL-008842393
GOOG-AT-MDL-008881638
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GOOG-AT-MDL-009013305
GOOG-AT-MDL-009070918
GOOG-AT-MDL-009644380
GOOG-AT-MDL-009754910
GOOG-AT-MDL-012683798
GOOG-AT-MDL-012693321
GOOG-AT-MDL-012693796
GOOG-AT-MDL-013211457
GOOG-AT-MDL-013262396
GOOG-AT-MDL-013274837
GOOG-AT-MDL-013288759
GOOG-AT-MDL-015236044
GOOG-AT-MDL-016353371
GOOG-AT-MDL-016353630
GOOG-AT-MDL-016354429
GOOG-AT-MDL-016354537
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GOOG-AT-MDL-018243919
GOOG-AT-MDL-018531517
GOOG-AT-MDL-018630622
GOOG-AT-MDL-019603579
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GOOG-AT-MDL-B-001602051
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GOOG-AT-MDL-B-002862417
GOOG-AT-MDL-B-003131145
GOOG-AT-MDL-B-003983972
GOOG-AT-MDL-B-005080323
GOOG-AT-MDL-B-005090414
GOOG-AT-MDL-B-005180695
GOOG-AT-MDL-B-005180709
GOOG-AT-MDL-B-007919337
GOOG-DOJ-05782415

GOOG-DOJ-13615596
GOOG-DOJ-14031764
GOOG-DOJ-14138199
GOOG-DOJ-14141075
GOOG-DOJ-14240302
GOOG-DOJ-14298902
GOOG-DOJ-14609574
GOOG-DOJ-14718539
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GOOG-DOJ-AT-01812188
GOOG-DOJ-AT-02134358
GOOG-DOJ-AT-02148683
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GOOG-DOJ-AT-02231173
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GOOG-NE-02343690
GOOG-NE-02345285
GOOG-NE-02635108
GOOG-NE-02643371
GOOG-NE-03632946
GOOG-NE-04415172
GOOG-NE-04427230
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GOOG-NE-05279363
GOOG-NE-06567200
GOOG-NE-06842715
GOOG-NE-07834872
GOOG-NE-09149436
GOOG-NE-10646295

GOOG-NE-10730420
GOOG-NE-10780865
GOOG-NE-10942712
GOOG-NE-11797719
GOOG-NE-11839088
GOOG-NE-11902954
GOOG-NE-12065295
GOOG-NE-12081744
GOOG-NE-12466643
GOOG-NE-12949161
GOOG-NE-13202025
GOOG-NE-13204729
GOOG-NE-13204977
GOOG-NE-13207241
GOOG-NE-13208126
GOOG-NE-13216501

GOOG-NE-13217060
GOOG-NE-13226622

GOOG-NE-13550381
GOOG-NE-13558460
GOOG-NE-13614574
GOOG-NE-13620081
GOOG-NE-13624783
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GOOG-TEX-00055792
GOOG-TEX-00074558
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GOOG-TEX-00260934
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GOOG-TEX-00830552
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GOOG-TEX-00857298
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XVI. APPENDIX B: MATERIALS CONSIDERED

A. Declarations, Depositions and ROG responses

a. Discovery Responses

All available discovery responses produced within the matter of The State of Texas, et al. v. Google, Case Number: 4:20-cv-00957-SDJ, including:

The Parties' amended initial disclosures;

The Parties' discovery responses and objections to Interrogatories, Requests for Admission, and Requests for Production; and

Google's written responses to Plaintiffs' Rule 30(b)(6) Notice.

b. Deposition Transcripts & Exhibits

All available deposition transcripts and exhibits within the matter of The State of Texas, et al. v. Google, Case Number: 4:20-cv-00957-SDJ, including:

Deposition and Exhibits of Alaska ([redacted]), May 3, 2024

Deposition and Exhibits of [redacted], May 15, 2024

Deposition and Exhibits of [redacted], April 23, 2024

Deposition and Exhibits of [redacted], May 2, 2024

Deposition and Exhibits of [redacted], May 2, 2024

Deposition and Exhibits of Arkansas ([redacted]), May 1, 2024

Deposition and Exhibits of [redacted], May 1, 2024

Deposition and Exhibits of [redacted], May 1, 2024

Deposition and Exhibits of [redacted], May 1, 2024

Deposition and Exhibits of [redacted] (April 1, 2024)

Deposition and Exhibits of [redacted], April 29, 2024

Deposition and Exhibits of [redacted] May 23, 2024

Deposition and Exhibits of [redacted], May 23, 2024

Deposition and Exhibits of [redacted], April 19, 2024

Deposition and Exhibits of [redacted], April 30, 2024

Deposition and Exhibits of [redacted], May 1, 2024

Deposition and Exhibits of [redacted] April 25, 2024

Deposition and Exhibits of [redacted], May 3, 2024

Deposition and Exhibits of [redacted], May 1, 2024

Deposition and Exhibits of Florida ([redacted]), April 22, 2024

Deposition and Exhibits of [redacted], May 3, 2024

Deposition and Exhibits of [redacted], May 3, 2024

Deposition and Exhibits of [redacted] May 17, 2024

Deposition and Exhibits of [redacted], May 3, 2024

Deposition and Exhibits of [redacted], May 2, 2024

Deposition and Exhibits of Idaho ([redacted]), May 3, 2024

Deposition and Exhibits of Idaho ([redacted]), May 3, 2024

Deposition and Exhibits of [redacted], April 23, 2024

Deposition and Exhibits of Indiana ([redacted]), April 26, 2024

Deposition and Exhibits of Indiana ([redacted]), April 26, 2024

Deposition and Exhibits of [redacted], May 1, 2024

Deposition and Exhibits of [redacted], April 26, 2024

Deposition and Exhibits of [redacted], April 25, 2024

Deposition and Exhibits of [redacted], April 16, 2024

Deposition and Exhibits of [redacted], May 10, 2024

Deposition and Exhibits of [redacted], April 23, 2024

Deposition and Exhibits of [redacted] May 24, 2024

Deposition and Exhibits of Kentucky ([redacted]), April 25, 2024

Deposition and Exhibits of [redacted], May 23, 2024

Deposition and Exhibits of [redacted], April 12, 2024

Deposition and Exhibits of [redacted], April 22, 2024

Deposition and Exhibits of Louisiana ([redacted]), May 3, 2024

Deposition and Exhibits of [redacted], April 3, 2024

Deposition and Exhibits of [redacted], April 30, 2024

Deposition and Exhibits of [redacted], April 17, 2024

Deposition and Exhibits of [redacted], May 1, 2024

Deposition and Exhibits of [redacted], May 2, 2024

Deposition and Exhibits of [redacted] April 30, 2024
Deposition and Exhibits of [redacted] May 2, 2024
Deposition and Exhibits of [redacted], May 21, 2024
Deposition and Exhibits of [redacted], May 22, 2024
Deposition and Exhibits of [redacted], April 22, 2024
Deposition and Exhibits of Mississippi ([redacted]), April 25, 2024
Deposition and Exhibits of Mississippi ([redacted]), April 25, 2024
Deposition and Exhibits of Missouri ([redacted]), May 10, 2024
Deposition and Exhibits of [redacted], May 2, 2024
Deposition and Exhibits of [redacted] May 1, 2024
Deposition and Exhibits of [redacted], May 2, 2024
Deposition and Exhibits of [redacted], May 1, 2024
Deposition and Exhibits of Montana ([redacted]), May 1, 2024
Deposition and Exhibits of [redacted], April 16, 2024
Deposition and Exhibits of [redacted], May 24, 2024
Deposition and Exhibits of Nevada ([redacted]), April 29, 2024
Deposition and Exhibits of [redacted] May 1, 2024
Deposition and Exhibits of [redacted], April 12, 2024
Deposition and Exhibits of [redacted] May 3, 2024
Deposition and Exhibits of [redacted] Vol 1, April 26, 2024
Deposition and Exhibits of [redacted] Vol 2, May 21, 2024
Deposition and Exhibits of [redacted] Vol 1, April 19, 2024
Deposition and Exhibits of [redacted] Vol 2, May 2, 2024
Deposition and Exhibits of [redacted] Vol 3, May 3, 2024
Deposition and Exhibits of [redacted] Vol 4, May 24, 2024
Deposition and Exhibits of North Dakota ([redacted]), May 2, 2024
Deposition and Exhibits of [redacted], April 30, 2024
Deposition and Exhibits of Puerto Rico ([redacted]), May 1, 2024
Deposition and Exhibits of [redacted], April 5, 2024
Deposition and Exhibits of [redacted], May 2, 2024

Deposition and Exhibits of South Carolina ([redacted]), April 23, 2024

Deposition and Exhibits of South Dakota ([redacted]), April 29, 2024

Deposition and Exhibits of [redacted], May 3, 2024

Deposition and Exhibits of [redacted], April 26, 2024

Deposition and Exhibits of [redacted], April 25, 2024

Deposition and Exhibits of Texas ([redacted]), April 17, 2024

Deposition and Exhibits of Texas ([redacted]), May 24, 2024

Deposition and Exhibits of [redacted], May 1, 2024

Deposition and Exhibits of [redacted], May 3, 2024

Deposition and Exhibits of [redacted] May 3, 2024

Deposition and Exhibits of [redacted] May 3, 2024

Deposition and Exhibits of [redacted] April 29, 2024

Deposition and Exhibits of [redacted] April 29, 2024

Deposition and Exhibits of [redacted], May 23, 2024

Deposition and Exhibits of [redacted], April 29, 2024

Deposition and Exhibits of [redacted], April 3, 2024

Deposition and Exhibits of Utah ([redacted]), April 30, 2024

Deposition and Exhibits of Utah ([redacted]), April 30, 2024

Deposition and Exhibits of [redacted] April 19, 2024

Deposition and Exhibits of [redacted], April 19, 2024

Deposition and Exhibits of [redacted]., April 25, 2024

Deposition and Exhibits of [redacted], April 12, 2024

All available deposition transcripts and exhibits within the matter of USA v. Google, Case Number: 1:23-cv-00108-LMB-JFA, including:

Deposition and Exhibits of [redacted] August, 16 2023

Deposition and Exhibits of [redacted] (November 14-15, 2023)

Deposition and Exhibits of [redacted] (August 11, 2023)

Deposition and Exhibits of [redacted] (November 2, 2023)

Deposition and Exhibits of [redacted] September 1, 2023

Deposition and Exhibits of [redacted] (April 1, 2024)

Deposition and Exhibits of [redacted] (November 3, 2024)
Deposition and Exhibits of [redacted] (April 29, 2024)
Deposition and Exhibits of [redacted], September 29, 2023
Deposition and Exhibits of [redacted] August 29, 2023
Deposition and Exhibits of [redacted] (August 16, 2023)
Deposition and Exhibits of [redacted] (August 16, 2023)
Deposition and Exhibits of [redacted] (November 7, 2023)
Deposition and Exhibits of [redacted] (November 7, 2023)
Deposition and Exhibits of [redacted] September 6, 2023
Deposition and Exhibits of [redacted] September 8, 2023
Deposition and Exhibits of [redacted] September 29, 2024
Deposition and Exhibits of [redacted] (November 9, 2023)
Deposition and Exhibits of [redacted] (November 9, 2023)
Deposition and Exhibits of [redacted] September 5, 2023
Deposition and Exhibits of [redacted] September 26, 2023
Deposition and Exhibits of [redacted], September 8, 2023
Deposition and Exhibits of [redacted], September 26, 2023
Deposition and Exhibits of [redacted] (November 15, 2023)
Deposition and Exhibits of [redacted] (November, 11, 2023)
Deposition and Exhibits of [redacted] (November 14, 2023)
Deposition and Exhibits of [redacted] August 9, 2023
Deposition and Exhibits of [redacted] August 31, 2023
Deposition and Exhibits of [redacted] (April 17, 2024)
Deposition and Exhibits of [redacted] September 22, 2023
Deposition and Exhibits of [redacted] September 28, 2023
Deposition and Exhibits of [redacted] September 8, 2023
Deposition and Exhibits of [redacted], September 21, 2023
Deposition and Exhibits of [redacted] (October 10, 2023 and November 8, 2023)
Deposition and Exhibits of [redacted] (October 10, 2023)
Deposition and Exhibits of [redacted] (October 30, 2023)

Deposition and Exhibits of [redacted], August 25, 2023

Deposition and Exhibits of [redacted], August 25, 2023

Deposition and Exhibits of [redacted] September 22, 2023

Deposition and Exhibits of [redacted] (November 14, 2023)

Deposition and Exhibits of [redacted] (30B6 errata only) (November 14, 2023)

Deposition and Exhibits of [redacted] (November 11, 2023)

Deposition and Exhibits of [redacted] (November 3, 2023)

Deposition and Exhibits of [redacted] (November 3, 2024)

Deposition and Exhibits of [redacted] (30(b)6) (November 14, 2023)

Deposition and Exhibits of [redacted] August 29, 2023

Deposition and Exhibits of [redacted] October 26, 2023

Deposition and Exhibits of [redacted] (August 29, 2023)

Deposition and Exhibits of [redacted] (August 15, 2023)

Deposition and Exhibits of [redacted] (April 3, 2024)

Deposition and Exhibits of [redacted], July 28, 2023

Deposition and Exhibits of [redacted] (November 16, 2023)

Deposition and Exhibits of [redacted] August 23, 2023

Deposition and Exhibits of [redacted] September 28, 2023

Google's First Amended Responses and Objections to Plaintiff's Third Set of Interrogatories (May 24, 2024)

Google's Response to Topic 45 of Plaintiff's 30(b)(6) Notice Served February 21, 2024 (As Narrowed by the Parties May 7, 2024 agreement)

Google's Responses and Objections to Plaintiff's Second Set of Interrogatories (April 8, 2024)

Plaintiff States Fourth Amended Complaint (May 5, 2023)

The Plaintiff States' Seventh Amended Responses & Objections to Google LLC's First Set of Interrogatories (May 3, 2024)

c. Expert Reports & Declarations

All available expert reports (with redactions) within the matter of USA v. Google, Case Number: 1:23-cv-00108-LMB-JFA, including:

Declarations of Google Employees

Declaration of [redacted] in support of Google's Objections to Plaintiffs' 30(b)(6) topic 55

2023.12.22 Expert Report of Gabriel Weintraub, GOOG-AT-MDL-C-000018734

2023.12.22 Expert Report of R. Ravi, GOOG-AT-MDL-C-000019017

2023.12.22 Expert Report of Robin S. Lee, GOOG-AT-MDL-C-000019273

2023.12.22 Expert Report of Rosa Abrantes-Metz, GOOG-AT-MDL-C-000019786

2023.12.22 Expert Report of Thomas S. Respess, GOOG-AT-MDL-C-000020106

2023.12.22 Expert Report of Timothy Simcoe, GOOG-AT-MDL-C-000020274

2024.01.13 Errata to Abrantes-Metz Expert Report, GOOG-AT-MDL-C-000020435

2024.01.13 Errata to Ravi Expert Report, GOOG-AT-MDL-C-000020437

2024.01.13 Errata to Respess Expert Report, GOOG-AT-MDL-C-000020440

2024.01.13 Errata to Simcoe Expert Report, GOOG-AT-MDL-C-000020467

2024.01.13 Errata to Weintraub Expert Report, GOOG-AT-MDL-C-000020471

2024.01.23 Chevalier Expert Report, GOOG-AT-MDL-C-000020474

2024.01.23 Ferrante Expert Report, GOOG-AT-MDL-C-000020714

2024.01.23 Ghose Expert Report, GOOG-AT-MDL-C-000020767

2024.01.23 Israel Expert Report, GOOG-AT-MDL-C-000021036

2024.01.23 Milgrom Expert Report, GOOG-AT-MDL-C-000021794

2024.01.23 Rinard Expert Report, GOOG-AT-MDL-C-000022191

2024.01.23 Shirky Expert Report, GOOG-AT-MDL-C-000022229

2024.01.23 Simonson Expert Report, GOOG-AT-MDL-C-000022290

2024.01.23 Skinner Expert Report, GOOG-AT-MDL-C-000022948

2024.02.13 Expert Rebuttal Report of Adoria Lim, GOOG-AT-MDL-C-000023002

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2024.02.13 Expert Rebuttal Report of Kenneth Wilbur, GOOG-AT-MDL-C-000023322

2024.02.13 Expert Rebuttal Report of R. Ravi, GOOG-AT-MDL-C-000023435

2024.02.13 Expert Rebuttal Report of Robin S. Lee, GOOG-AT-MDL-C-000023516

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2024.02.13 Expert Rebuttal Report of Wayne Hoyer, GOOG-AT-MDL-C-000024138

2024.02.13 Expert Rebuttal Report of Wenke Lee, GOOG-AT-MDL-C-000024270

2024.02.16 Errata to Ravi Rebuttal Report, GOOG-AT-MDL-C-000024387

2024.02.20 Errata to Simcoe Rebuttal Report, GOOG-AT-MDL-C-000024389

2024.02.23 Errata to Weintraub Rebuttal Report, GOOG-AT-MDL-C-000024390

2024.02.23 Supplemental Errata to Weintraub Expert Report, GOOG-AT-MDL-C-000024391

2024.02.24 Errata to Wilbur Rebuttal Report, GOOG-AT-MDL-C-000024392

2024.02.26 Errata to Hoyer Rebuttal Report, GOOG-AT-MDL-C-000024397

2024.02.28 Errata to Abrantes-Metz Rebuttal Report, GOOG-AT-MDL-C-000024399

2024.03.04 Expert Supplemental Report of Robin S. Lee, GOOG-AT-MDL-C-000024403

2024.03.08 Consolidated Errata to Lee Rebuttal Report, GOOG-AT-MDL-C-000024436

2024.01.13 Expert Report of Weintraub Errata, GOOG-AT-MDL-C-000040965

2024.01.13 Expert Report of Simcoe Errata, GOOG-AT-MDL-C-000040961

2024.01.13 Expert Report of Respess Errata_with Figure Errata_Redacted, GOOG-AT-MDL-C-000040934

2024.01.13 Expert Report of R Ravi Errata, GOOG-AT-MDL-C-000040931

2024.01.13 Expert Report of Abrantes-Metz Errata, GOOG-AT-MDL-C-000040929

2024.03.08 Consolidated Errata to Lee Rebuttal Report, GOOG-AT-MDL-C-000040926

2024.03.04 Expert Supplemental Report of Robin S. Lee, PhD, GOOG-AT-MDL-C-000040893

2024.02.28 Rebuttal Report Errata of Rosa Abrantes-Metz Signed, GOOG-AT-MDL-C-000040889

2024.02.25 Expert Rebuttal Report of Hoyer Errata, GOOG-AT-MDL-C-000040887

2024.02.24 Wilbur Rebuttal Errata, GOOG-AT-MDL-C-000040882

2024.02.23 Weintraub Rebuttal Report Errata, GOOG-AT-MDL-C-000040881

2024.02.23 Expert Report of Weintraub Supplemental Errata, GOOG-AT-MDL-C-000040880

2024.02.20 Errata to Simcoe Rebuttal Report, GOOG-AT-MDL-C-000040879

2024.02.16 Errata to Ravi Rebuttal Report (Highly Confidential), GOOG-AT-MDL-C-000040877

2024.02.13 Rebuttal Report of Rosa Abrantes-Metz, GOOG-AT-MDL-C-000040700

2024.02.13 Expert Report of Wenke Lee, GOOG-AT-MDL-C-000040583

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2024.02.13 Expert Rebuttal Report of Timothy Simcoe_Redacted, GOOG-AT-MDL-C-000040377

2024.02.13 Expert Rebuttal Report of Robin S. Lee_Redacted, GOOG-AT-MDL-C-000040006

2024.02.13 Expert Rebuttal Report of R Ravi, GOOG-AT-MDL-C-000039925

2024.02.13 Expert Rebuttal Report of Kenneth Wilbur_Redacted, GOOG-AT-MDL-C-000039812

2024.02.13 Expert Rebuttal Report of Gabriel Weintraub_Redacted, GOOG-AT-MDL-C-000039716

2024.02.13 Expert Rebuttal Report of Adoria Lim_Redacted, GOOG-AT-MDL-C-000039492

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XVIII. APPENDIX D: CURRICULUM VITAE OF DR. JACOB HOCHSTETLER

[DOCUMENT STARTS ON THE FOLLOWING PAGE]

JACOB HOCHSTETLER, PhD

(940) 765.9451 | jacob.hochstetler@gmail.com | GitHub Profile | LinkedIn | ResearchGate

Education

Ph.D. – Computer Science and Engineering – University of North Texas, Denton, TX – 2021

Dissertation: An Extensible Computing Architecture Design for Connected Autonomous Vehicle System

Advisor: Dr. Song Fu

Master of Science – Computer Science – UNT – 2018

Bachelor of Science – Computer Science – UNT – 2011

Skills

Main (knowledge and daily experience):

- Languages: Go, Python, Ruby, Shell (bash/csh/zsh), TypeScript/JavaScript, LaTeX
- Frameworks: Chef, Ansible, React, VueJS, Vuetify (Material Design), k8s, Prometheus, Rails, gRPC
- Etc.: Lambda, DynamoDB, PostgreSQL, CockroachDB, Argo, Helm, Jenkins, Docker, Terraform, Envoy

Experienced (used in the past):

- Languages: ObjC, Swift, Java, C/C++, Perl, Tcl/Tk, VBScript/PS, R/Shiny
- Frameworks: Bootstrap, SASS, AngularJS, ELK, Django
- Etc.: Percona (MySQL), Hadoop, Solr, Redis, Packer, Splunk, OpenStack, RabbitMQ

Publications

- *Cooperative Mixed Reality Leveraging Edge Computing and Communication* – 5th ACM/IEEE Symposium on Edge Computing (SEC) – 2020
- *Low-latency High-level Data Sharing for Connected and Autonomous Vehicular Networks* – IEEE Intl. Conf. on Industrial Internet (ICII) – 2019
- *An Empirical Study of Quad-Level Cell (QLC) NAND Flash SSDs for Big Data Applications* – IEEE Intl. Conf. on Big Data (Big Data) – 2019
- *Embedded Deep Learning for Vehicular Edge Computing* – 3rd IEEE/ACM Symposium on Edge Computing (SEC) – 2018
- *Reliability Characterization of Solid State Drives in a Scalable Production Datacenter* – IEEE Intl. Conf. on Big Data (Big Data) – 2018
- *Incorporate Proactive Data Protection in ZFS Towards Reliable Storage Systems* – IEEE 16th Intl. Conf. on Dependable Computing (DASC) – 2018
- *Developing Cost-Effective Data Rescue Schemes to Tackle Disk Failures in Data Centers* – Springer Intl. Conf. on Big Data – 2018
- *An Optimal Police Patrol Planning Strategy for Smart City Safety* – IEEE 14th Intl. Conf. on Smart City (SmartCity) – 2016

Clearances & Certifications

- **TS/SCI** – DoD – 1997
- **Counter-intelligence polygraph** – DoD – 1997
- **Full-scope polygraph** – CIA – 2003
- **Security+** – CompTIA – 2010
- **ITILv3 Certified** – AXELOS – 2010
- **Sun Certified System Administrator (SCSA)** – Sun Microsystems – Solaris 8 & 2.6
- **Sun Certified System Support Engineer (SSE)** – Sun Microsystems – 2002
- **Cisco Certified Network Associate (CCNA)** – Cisco – 2000

Litigation Support & Expert Witness Experience

Cellspin Soft, Inc. v. Fitbit, Inc., et al. – Garteiser Honea – CA Northern District, 4:17-cv-05928 2020 to 2021

- *Matter*: Patent Infringement, Digital Data capture with Bluetooth interface
- *Provided*: Seven code reviews

InfoGation Corp. v. Google LLC – Sheridan Ross PC – TX Western District 6:20-cv-0366 2020 to 2022

- *Matter*: Patent Infringement, Mobile Navigation System
- *Provided*: Code review

Tactical Entertainment, LLC v. Krasamo, Inc. – Creedon PLLC – TX 401st District, 401-03246-2017 2019 to 2021

- *Matter*: Software development, Back-end services, APIs, and Networking
- *Provided*: Code review

Teaching Experience

Clinical Assistant Professor, University of North Texas, Denton, TX

- CSCE3055 – *IT Project Management*: Microsoft Project, SDLC, Agile development, Git, Basecamp, Project Finance, Google Analytics.
- CSCE3220 – *Human Computer Interfaces*: UI/UX, Adobe XD, Web Accessibility, iOS UI and Android UI kits.
- CSCE3420 – *Internet Programming*: PHP, JavaScript, Node.js, HTML/CSS, Client/Server architecture, APIs, AWS Lambda.
- CSCE3530 – *Introduction to Computer Networks*: OSI Model: MAC, Ethernet, TCP/IP, Proxies/Load Balancers, Application layer.
- CSCE3550 – *Foundations of Cybersecurity*: Security goals, threats, vulnerabilities. Network, program, and operating system security issues.
- CSCE4350 – *Database Systems*: SQL, MySQL, Object Stores, NoSQL, AWS DynamoDB.
- CSCE4560 – *Secure Electronic Commerce*: Shopping carts/Payment gateways, eCommerce security, PKI, SSL/TLS, AuthZ/AuthN, Blockchain.
- CSCE4600 – *Operating Systems*: system abstraction/virtualization, process/threads concurrency, persistence (resource management), security.
- CSCE5552 – *Cybersecurity Essentials*: Data concealment/obfuscation, system identity/reconnaissance/exploitation, cryptography, data forensics.
- CSCE5585 – *Advanced Network Security*: Firewalls, intrusion prevention/detection systems, network forensics, network pentesting.

Research Experience

University of North Texas, Dependable Computing Systems Lab, Denton, TX

- Data format and protocol end-to-end architecture for connected vehicle data sharing.
- Embedded/Single board computer edge node clustering using Rancher k3s and k3os.
- Autonomous, self-driving system using Nvidia PX2 with Lidar, Radar, and image sensors on a Polaris GEM (with NSF).
- Edge node-style hard-drive deployments using single-board computers embedded in HDD PCBs (in partnership with HP Labs).
- Real-time machine learning with Microsoft HoloLens for augmented reality and a single-board computer for inference.

Los Alamos National Labs, Department of Energy, Trinity, Los Alamos, NM

- Machine learning log HPC analysis.
- Singularity container system to deploy HPC workloads.

Work History

Vice President, Personal Investing, Cloud Engineering [Distinguished Engineer] – Fidelity Investments – Westlake, TX 2022 to Present

- Provided technical oversight to Fidelity's Personal Investing (PI) Platform Engineering teams as a Distinguished Engineer.
- Created app-team level self-service routing based on multiple Envoy routers, both through public and on-premise datacenters.
- Developed "next-gen" Golang skeleton/framework for high-performance (high-TPS) applications.
- Facilitated high-level and cross-business unit architecture design teams.

Clinical Assistant Professor, Department of Computer Science and Engineering – University of North Texas – Denton, TX 2021 to Present

- Taught undergrad and graduate level computer science, information technology, and cybersecurity courses.
- Developed online curriculum for multiple classes.
- Led NSA/NSF GenCyber student and teacher summer camps [2022, 2023].
- Chaired multiple hiring committees, resulting in onboarding eight faculty members.
- Served as Computer Science curriculum program advisor.

Director, Infrastructure as a Service Development/Product Owner/IC – Fidelity Investments – Westlake, TX 2018 to 2022

- Led a "two-pizza team" developing an on-premise cloud management platform with Kanban-style feature delivery.
- Acted as lead individual contributor to application architecture, design, and development.
- Mentored junior developers on best practices in SDLC, CI/CD, and infrastructure automation/orchestration.
- Led stability project in migrating a decade-old legacy Python codebase to Golang.

Principal Software Engineer/Cloud Technologist – Fidelity Investments – Westlake, TX 2016 to 2018

- Maintained API (Python) and UI (Rails/AngularJS) for an on-premise cloud management platform.
- Provided DevOps support for both the cloud management platform and underlying infrastructure (Citrix XenServer, OpenStack, and AWS EC2).
- Developed "Day 0", "1" and "2" automation through Chef and Ansible to meet security, compliance and audit requirements.

Senior Software Engineer – Fidelity Investments – Westlake, TX 2015 to 2016

- Led project to automate end-user SSH PKI Lifecycle Management within Fidelity.
- Developed highly available architecture composed of master-master DB nodes surrounded by "dumb" API and UI nodes.
- Used `fpm` to create packages for Solaris, Red Hat, Debian (Ubuntu), and AIX for seamless user integration (`opensshd/sshd`) with the PKI portal.

UNIX Systems Lead – General Dynamics – SW Asia 2011 to 2014

- Maintained UNIX systems for the US Air Force Central Command Intelligence, Surveillance and Reconnaissance Division.
- Provided Subject Matter Expertise to A6/G6/J6 commands, along with down-range assets.
- Developed real-time, self-service web services to replace business processes for the Change-Advisory Board, increasing delivery to customers.

JWICS Systems/C2 Systems Lead – General Dynamics – SW Asia/HOA/AFG/IRQ 2010 to 2011

- Supported core JWICS hardware/software including VMware, Solaris, NetApp filers, Windows, and Red Hat Enterprise Linux (RHEL).
- Maintained multiple JSTARS Workstations, Approver for Radiant Mercury in training and live environments.

Sun Engineer (Onsite) – General Dynamics – Plano, TX 2007 to 2010

- Provided on-site support to the EDS (later HP) datacenter for Sun Microsystems/Hewlett Packard/General Motors/OnStar.
- Developed in-house application to manage personnel rotations and inventory at all Sun-managed datacenter to meet SLAs.

C2 Systems Administrator – General Dynamics – SW Asia 2006 to 2007

- Installed, configured and maintained Solaris-based Command and Control systems at the Combined Air Operations Center.
- Trained end-users and maintainers on JSWS, Radiant Mercury, and Information Support Server Environment guard.
- Created and maintained Continuity of Operations (COOP) plans and documentation.

GCCS Administrator/COP Manager – General Dynamics – SW Asia 2005 to 2006

- Provided on-site operational and functional support as the Common Operational Picture manager at the Combined Air Operations Center.
- Managed the flow of information between the SIPR, CSV, CENTRIX, GCC+2 networks, Administered DII-COE GCCS cluster on Solaris 2.5.1.
- Manipulated displays and ground, air and sea tracks for local C2PC clients and downstream feeds.

Sun Microsystems Subject Matter Expert Engineer (Onsite SME) – General Dynamics – SW Asia/AFG/IRQ 2004 to 2005

- Conducted hardware and software fault isolation, root cause analysis and repair on Sun Microsystems servers, storage arrays, and workstations.
- Provided continual training to military personnel in the operation of Solaris and Sun Microsystems equipment.

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Security Contractor – Academi (formerly Blackwater Security Company) – SW Asia/IRQ 2003 to 2004

- Conducted personal security detail and training operations for the US and Iraqi military.

Field Engineer – General Dynamics – San Jose, CA 2000 to 2002

- Serviced Sun Microsystems equipment at secure (GOV/MIL) and commercial customer sites.
- Developed in-house reporting tools to gather email and SMS messages, parse them for job information, and assign escalation queues.

Counter-Intelligence Agent – US Army 1996 to 2005

- Provided CI duties as a human intelligence (HUMINT) agent to sliced elements.
- Surveilled, interviewed, and interrogated human sources, and analyzed open-source (OSINT) intelligence.
- Engaged in security/force-protection operations involving intelligence collection, processing, producing, and dissemination.